POWER

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Shall He Take a Chance?

A READER of *Power* describes a situation that is not uncommon, at least in some of its particulars.

He is forty-five years old, served his apprenticeship as a machinist, went to sea as an engineer, worked as watch engineer for a power company, went back to sea when the war broke out and earned a chief engineer's unlimited license. He is now chief watch engineer for a large public utility. He has seen the plant remodeled, engines displaced by turbines and modern apparatus installed. In all this he has taken an intimate and active part.

Although he has attended no technical school and has no degree, he has been a reader, observer and student and has watched and taken part in the application of the principles that he has learned and the developments that he has followed, until he is convinced that he has a knowledge of design and construction and the economical assemblage and operation of steam and electrical machinery that would make him valuable to somebody in a broader position than that of watch engineer.

He has evidently been thrifty and successful, for he says that under present conditions he can retire with a competency within a few years, but he is still interested and virile and feels that he should be able to use to advantage the capital of knowledge and experience that he has been acquiring through years of study and practical work.

He writes a good letter and is evidently a man of more than ordinary intelligence. He is thinking of putting out his shingle as a consulting engineer.

There are too many and too conspicuous examples of successful engineers who have attained eminence without the advantage of having attended engineering schools or colleges to make this handicap — and it is a handicap — the reason for not cutting loose from the payroll.

It is entirely possible for a man to amass, in twenty-odd years of practical opportunity and self-education, experience and knowledge that people are willing to buy and be guided by in spending their money.

But a successful consulting engineer must have qualities beyond those of laying out a plant for a given purpose and making it run.

In the first place he must be able to sell himself and his services; to convince others that he has knowledge and ability out of the ordinary.

This requires assurance and self-assertion, which is sometimes a larger part of the stock in trade of the practitioner than his real engineering ability. On the other hand, the lack of it in sufficient amount has kept many a man who really had the goods in a subordinate position.

The public utilities offer the most numerous opportunities for the exercise of just the sort of ability that this man describes. Some of the most eminent of power-plant engineers have risen to their positions of emolument and responsibility through such training and practice as he has been through.

It has been no small part of the work of the projectors and managers of this rapidly growing industry to keep their operating organizations intact, to find men who are competent and willing to undertake large engineering responsibilities, to recognize especial merit and ability among their personnel and build it into the system to their own and its possessor's advantage.

One wonders why, with the qualifications of a consulting engineer, one should have remained so long a member of the watch.

Was it because, through diffidence and modesty, he has failed to let his higher qualities be known? Have none of the opportunities for the larger use of this special knowledge come his way, making it necessary for him to go outside of the field of its natural application, or is there some other characteristic, or lack of it, that has held him back and would hamper his management of himself and his own business?

Has he the breadth of vision that sees the whole picture and not alone its practical mechanical details? Has he executive as well as engineering ability? Does he know as much about the worth of a dollar as of a B. t. u? Can he compute the earning power of an installation as well as its horsepower?

I do not know, and I am incompetent to advise him. But I state his case because, as I started by saying, it is typical of that of many others who feel that they have acquired knowledge and ability beyond that which they have any opportunity to exercise in their present circumscribed positions.

F. R. Low

First Station to Use 1200-lb. Steam Pressure

Requested for an introductory statement to the Weymouth description I. E. MOULTROP of the Edison Electric Illuminating Company of Boston says:

IN BUILDING WEYMOUTH we faced conditions somewhat different from the ordinary. The system load factor is low, due largely to the comparatively small amount of manufacturing in and around Boston. There is, moreover, little prospect that it will ever be materially increased. The price of coal is quite high owing to the long haulage from the mines.

The problem of supplying the community with cheap and adequate electrical energy was, therefore, a difficult one, especially as little help could be expected from water power within reasonable transmission distances, because they are all quite completely developed.

The lack of a large base load made a regenerative cycle such as is in use at Philo impracticable, because the unit cost of such a plant is high and because of the large percentage of time this expensive apparatus would have to be run at poor efficiency or stand idle.

Therefore, it seemed wise to build upon standard lines (so that the cost of construction would be low and the efficiency as high as possible) a station that would take the fluctuations of our load and superimpose upon this station enough high-pressure units (1,200 lb.) to carry the base load of the system with the best possible efficiency.

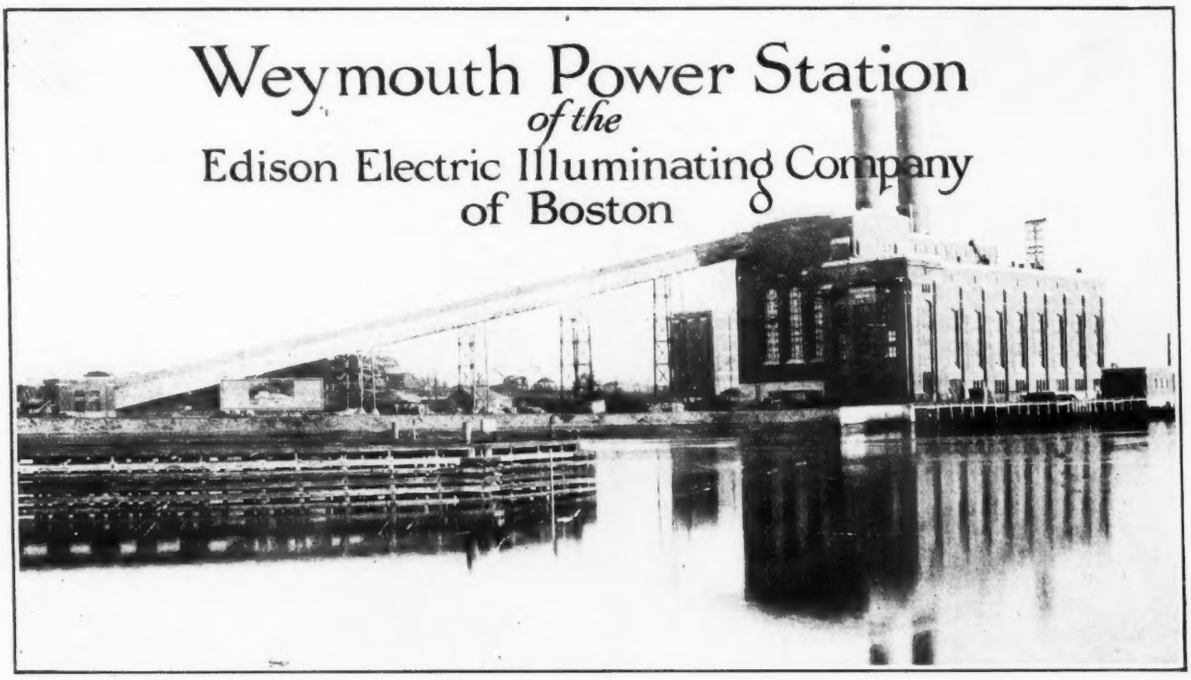
Of course Weymouth could be run for a time as a base-load station, but with the growth of the business it would be only a short time before it would have to take the load factor of the system.

This station design is very flexible, because high-pressure units can be added in proportion to the increase in base load. It also permits the operation of all units in service at good efficiency.

The cost of the installation as made is not greater per unit of capacity than that of a standard station for the steam conditions adopted; namely, 350 lb. pressure at 700° F. temperature. While the high-pressure boiler and turbine cost more, nearly all auxiliaries are eliminated.

Other interesting features of the station are the provisions for intelligent operation of the boilers, the grouping of apparatus to minimize operating labor and the provisions made to eliminate fire and accident hazards. Operating labor has been brought to the irreducible minimum. The safety features are quite elaborate; they cost considerable money, but we believe it is money well invested, and we are also doing our bit to reduce human suffering.

Weymouth Power Station *of the* Edison Electric Illuminating Company of Boston



IN DESIGNING the Weymouth Station, a broad study was made of the effect of variation in steam temperature and pressure upon plant efficiency. The temperature at which the steam should be supplied to the turbine is almost entirely a problem of material, as the beneficial effect of superheat, although largely indirect, continues in worth-while proportion up to the maximum temperature that our engineering materials will properly withstand. Although temperatures as high as 750 deg. to 800 deg. F. have been used, it was decided that for Weymouth the conservative value of 700 deg. should be the maximum temperature regardless of the pressure adopted.

Theoretically, an increase in steam pressure, temperature being held constant, gives an increase in turbine efficiency. In practice, however, this is counteracted by an increasingly greater loss in the actual machine efficiency, due to the density of the steam increasing the windage and friction losses, and the lessened possible superheat which allows condensation to take place at an earlier stage in the expansion. The net result is a relatively great increase in efficiency due to increase in pressure up to approximately 400 lb. From here to around 600 lb. the gain is very slight, and beyond that point present commercial efficiencies indicate a loss. Commercial standards and costs modified theoretical considerations to such an extent that for this plant a nominal pressure of 350 lb. gives the best net over-all efficiencies when taking into account investment charges.

A study of reheating showed that if reheating of the steam was employed, the initial pressure could be advantageously increased to a very high point. While reheat was not advisable for the plant as a whole, for a portion of the plant, suitable for base-load operation, it presented possibilities of increased efficiency.

The manufacturers of the principal equipment involved were prepared to go as high as 1,200 lb. This presented the possibility of installing a unit operating at that pressure, exhausting through a reheater, where the steam would be brought back to its original temperature of 700 deg. and then discharging into the main steam header supplying the basic 350-lb. units. The estimated cost of the combined 350-lb. and 1,200-lb. installation showed that the cost per kilowatt would not be any greater than for that of the 350-lb. plant owing to the fact that the equipment and parts subjected to 1,200 lb. are only a comparatively small portion of the entire plant and that the increase in plant capacity would bring the unit cost down to the basic figure. The thermal savings in over-all plant efficiency were well worth while and the equipment could be installed and operated without in any way interfering with or complicating the basic 60,000-kw. plant. It was therefore decided to install a 1,200-lb. steam plant having a total capacity, high- and low-pressure stages, of approximately 15,000 kilowatts.

The power station buildings are of selected red brick. The interior of the turbine room is finished with a white and gray enamel brick, laid up in a simple paneled design without ledges and dirt-collecting corners. The floors are of red tile with black borders. In the boiler room a glazed buff brick has been used for the interior walls to give ease of cleaning and improve the lighting. All exposed steel and iron work is covered with a light shade of paint.

The end of the turbine room nearest the main highway, called the permanent end, has been developed as an office or administration building.

The coal-storage plant was designed on the basis of a 350,000-kw. station and also to serve as an emergency storage for the entire Boston Edison system. The present development provides a storage capacity of 100,000 tons.

One of the elements controlling the design was the fact that not only large unloading capacity was required to discharge the 8,000- to 12,000-ton colliers, but in common with all New England coast stations the plant may have to discharge also, schooners or lighters having small hatches. This called for small bucket, high-speed

unloading towers; and, to keep down demurrage charges on the large steamers, the ability to use the unloading equipment to its full capacity at all times. To meet these requirements the following plant was installed:

For unloading coal there are two electrically operated hoisting towers which travel on a trestle 30 ft. high. These have 2-ton buckets and each has an unloading capacity of 400 tons an hour. The towers have shuttle discharge conveyors which normally deliver the coal to conveyor belts on the elevated trestle. By extending the shuttles, the towers can discharge the coal direct to an emergency or "cushion" pile at the rear of the trestle. This latter method of operation gives great flexibility and makes available at all times the unloading capacity of any number of towers.

The coal, if delivered to the trestle belt, is carried either directly to the power station, passing through a Bradford breaker on the way, or to a 250-ft. gantry bridge. The bridge has a double cantilever projection on the end nearest the trestle, arranged so that the lower arm extends under the trestle belt and the upper arm above the belt. The lower arm and main bridge truss carry a belt conveyor with tripper. If the coal is being delivered to the bridge, the tripper on the trestle belt is placed opposite that piece of apparatus and the coal tripped off to the stocking belt onto the lower arm, by means of which it is delivered to any part of the storage pile. Coal is reclaimed from storage by means of a 6-ton man-operated trolley on the gantry bridge, which delivers to the bridge hopper from where an inclined apron conveyor on the upper arm of the bridge delivers to the trestle belt, thence to breaker and power station.

The reclaiming bucket also runs on the cantilever portion of the bridge, enabling coal that may have been put in the cushion pile to be reclaimed and placed in the main storage.

The present belt system is of 400 tons per hour capacity, with one line of belts installed throughout, but all provision is made for duplication. This duplication provides relay and also if both systems of belt are operated it will give a capacity of 800 tons per hour.

Four Boilers in Initial Installation

The initial boiler installation consists of three normal pressure boilers and one high-pressure boiler. The former deliver steam at 350 lb. and 700 deg. temperature. They are cross-drum type, 48 tubes wide and 17 high, containing 19,743 sq.ft. of boiler-heating surface each. The superheaters are of the convection type located above the sixth row of boiler tubes. It was originally intended to use 14-tube high boilers as being well suited for an economizer installation, but it was found that by rearranging the slag screen and lower banks of tubes, an arrangement giving much better accessibility and three additional rows of tubes would be secured without changing the over-all measurements. These three additional rows of tubes were thus obtained at a nominal cost.

Between each boiler and its economizer is a cinder catcher. The furnace arrangement provides for firing from the low end of the boilers. The stokers are of the underfeed type with clinker grinders, there being 16 retorts per boiler.

The boilers are arranged with their back or uptake ends facing a central operating aisle and their fronts or stokers facing outside firing aisles. The firing aisles are partitioned off from the remainder of the boiler room and are used for coal feed only. Coal is normally fed to the stoker hoppers by means of stationary chutes supplied from bunkers over the firing aisles. A 6-ton traveling weigh larry is installed in each firing aisle. This is for use during tests and for supplying coal to boilers from bunkers not directly overhead. The central aisle contains the boiler controls, instruments and furnace observation doors and is therefore the real operating aisle. This arrangement gives clean, light and well-ventilated working quarters for the highly skilled boiler-room force.

Forced and Induced Draft Equipment

The forced-draft fan equipment consists of one fan and motor for each boiler. This equipment is in a chamber partitioned off from the ash basement. Air for combustion is primarily supplied through louvers in the outside wall. Warm air from the upper part of the boiler room can also be discharged into this chamber and drawn in by the suction of the forced-draft fans. The discharge ducts are arranged so that any fan can be used to supply its individual boiler, any other boiler or group of boilers. Normally, it is expected to operate a fan on its own boiler. The motors are of the a.c. brush-shifting variable-speed type.

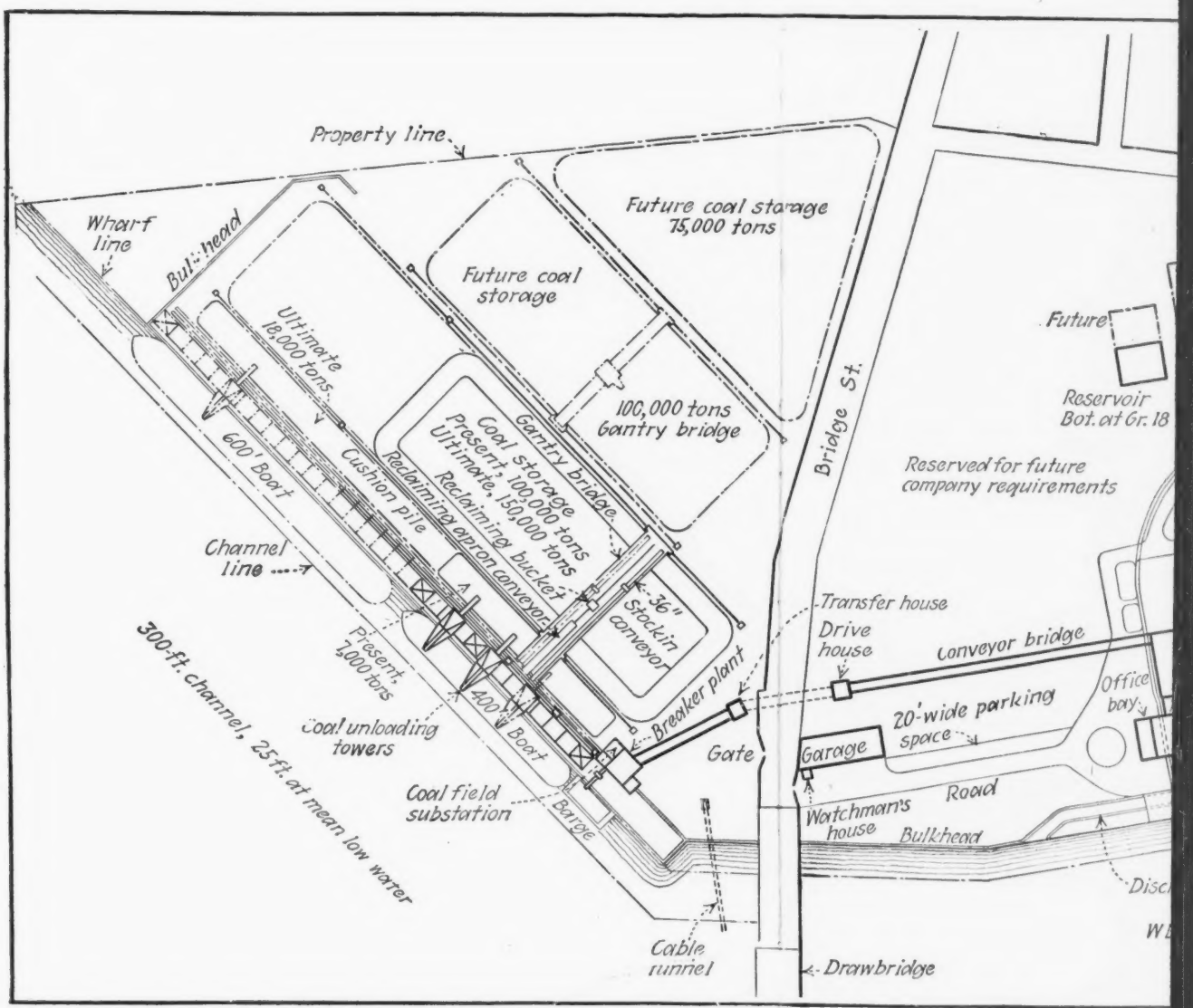
Each boiler has an induced-draft fan beside the economizer with slip-ring motor on one end of its shaft and a smaller similar type motor on the other end. The controls are arranged so that the smaller motor carries the load to the limit of its speed range at which point the larger motor automatically cuts in and carries it from there on.

The output and efficiency of each boiler are controlled from a board in the operating aisle at the back of the boiler. This board has on it the necessary instruments to guide the operator and push buttons to regulate the speed of the forced-draft, induced-draft fan, and stoker motors. These functions can also be controlled automatically by the relation of steam flow to furnace air flow. There is also a central board from which the output of any or all of the boilers can be controlled manually or automatically from steam pressure, thus maintaining uniform and stable steam conditions for the turbines.

Main Generating Equipment

The initial main generating equipment consists of two 32,000-kw. turbines each driving a 30,000-kw. 14,000-volt 60-cycle main generator and a 2,000-kw. 2,300-volt 60-cycle auxiliary generator direct connected to the shaft of the main generator. The turbines are supplied with steam at a nominal pressure of 350 lb. and a total temperature of 700 deg. F. There is also a 3,000-kw. high back-pressure turbine direct connected to a 14,000-volt 60-cycle generator. This turbine takes steam up to 1,200 lb. pressure and 700 deg. F. and exhausts through a reheater into the 350-lb. system.

The main units are installed on a platform with their axes parallel to the length of the turbine room, thus giving light and ease of access to the auxiliaries below and also approximately equivalent growth between the turbine and boiler room as the plant increases in size. The steam ends of each two units are adjacent, with one condensing water intake and tunnel serving two units. From an operating point of view two main units are considered as one group, and with this in mind, their auxiliaries have been located symmetrically around the transverse center line of the group.

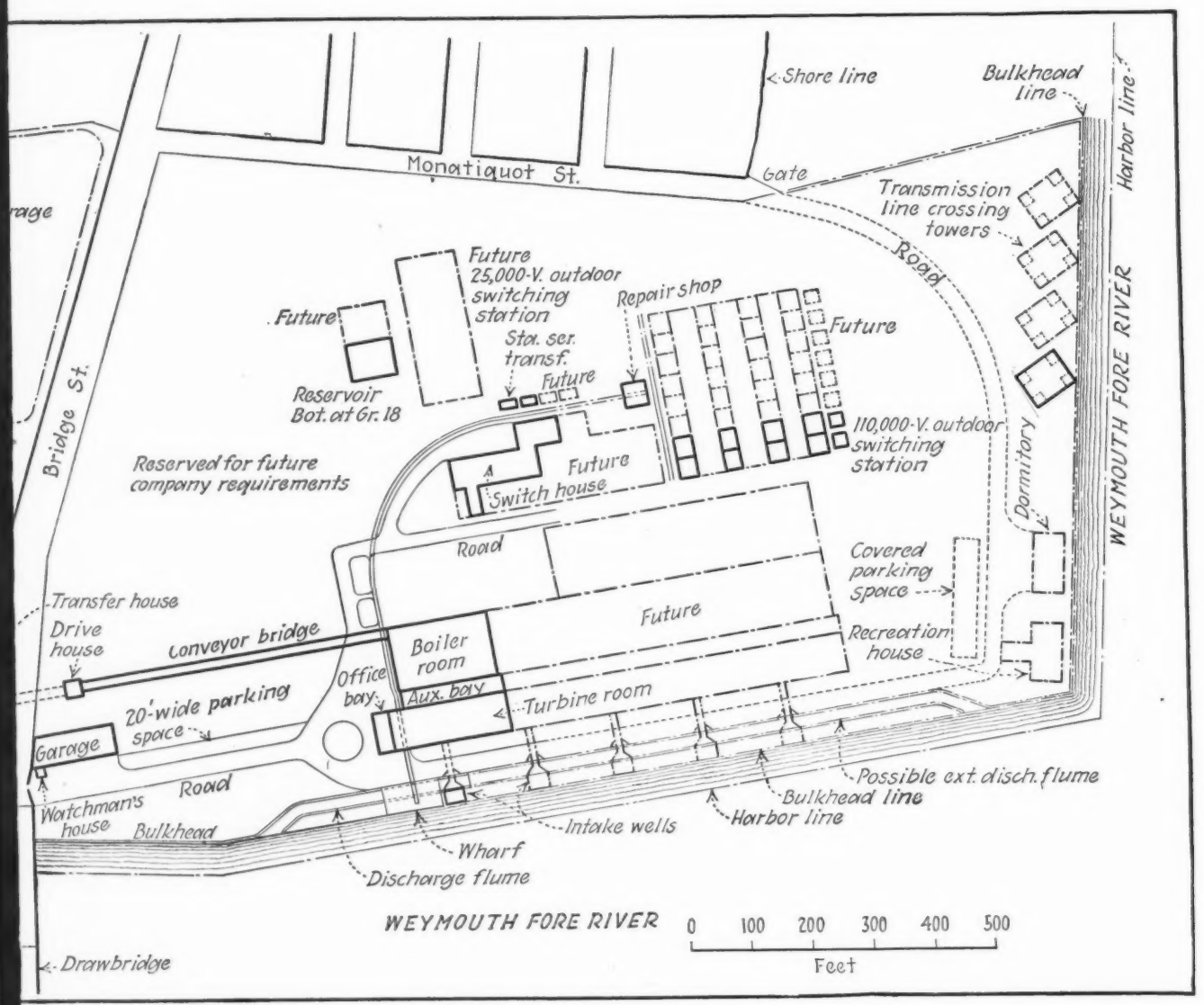


Section Through Weymouth Station

of the

Edison Electric Illuminating Co. of Boston

Contains First 1200 Lb. Pressure Boiler and Turbine



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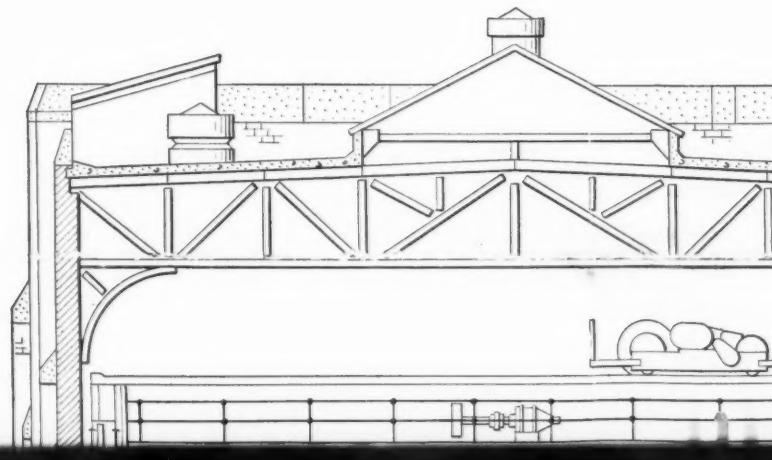
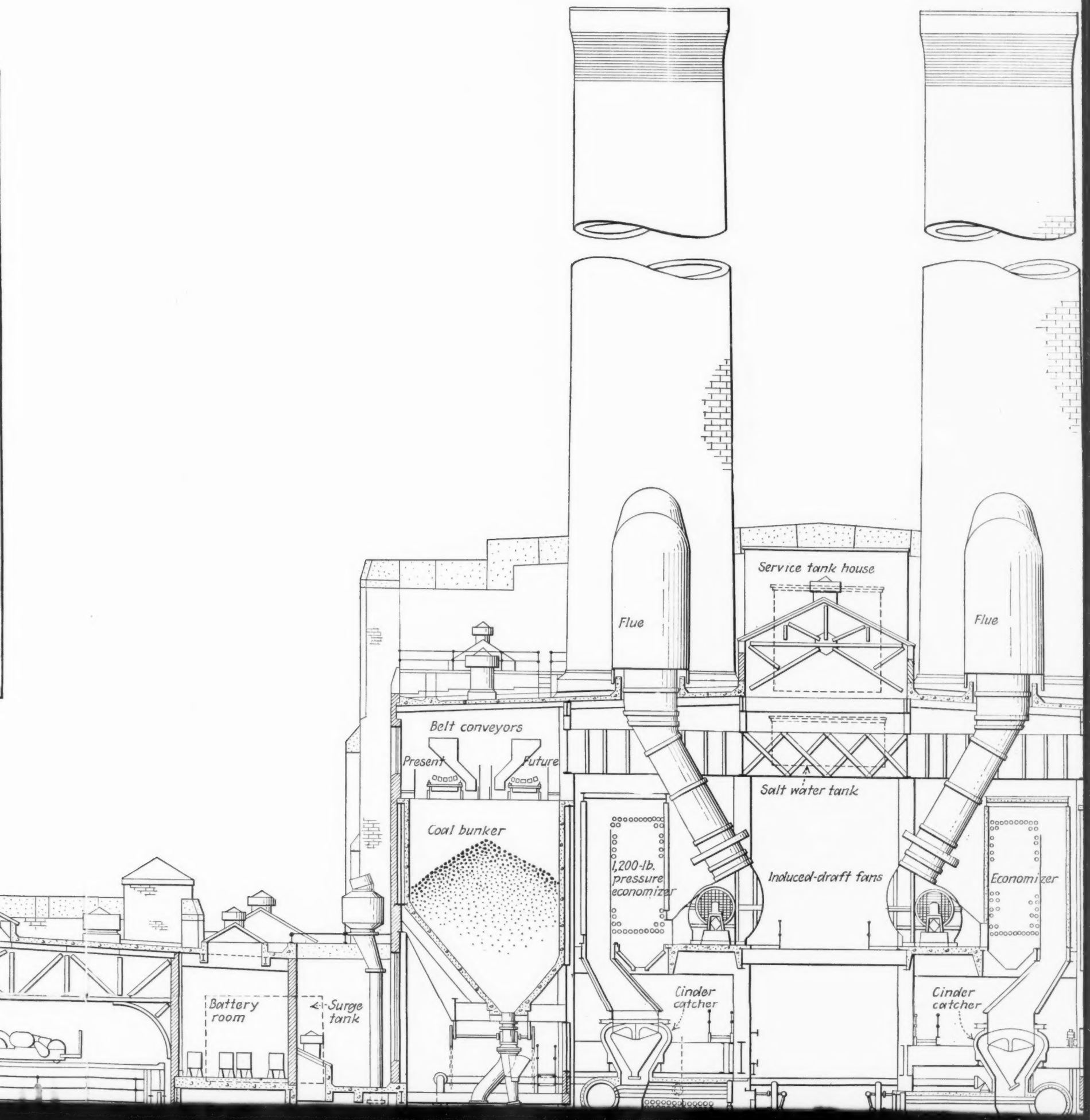
Co. of Boston

and Turbine



Contains First 1200 Lb. Pressure Boiler and Turbine



Flue

Flue

Service tank house

Belt conveyors

Present

Future

Salt water tank

Coal bunker

1,200-lb. pressure economizer

Induced-draft fans

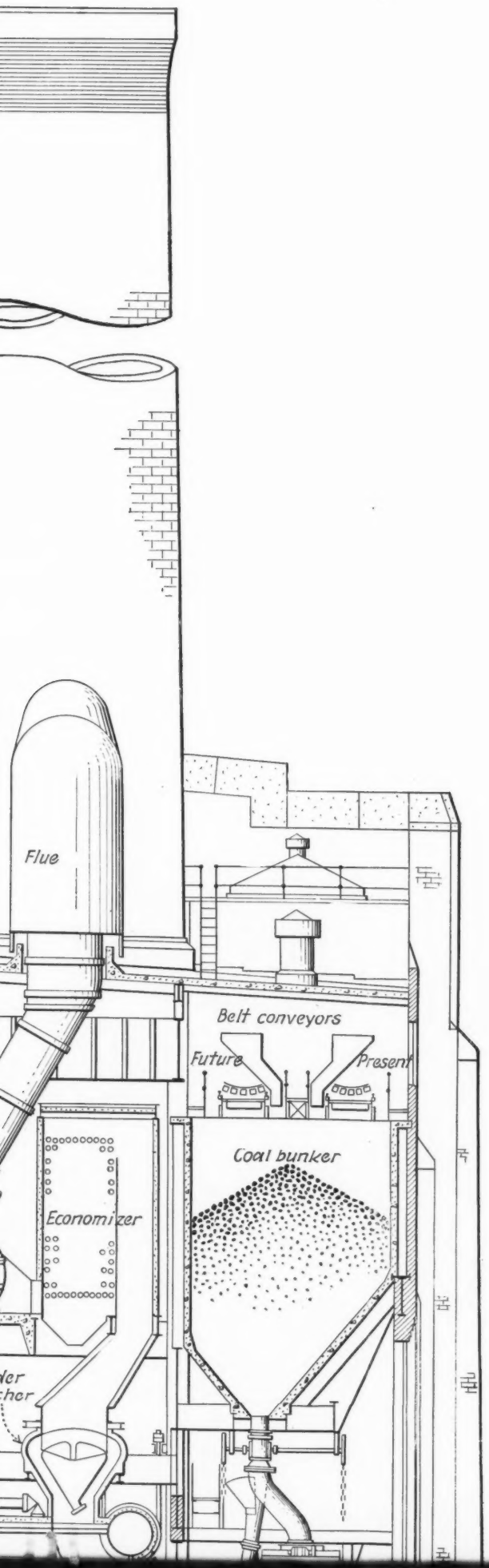
Economi

Battery room

Surge tank

Cinder catcher

Cinder catcher


Flue
Belt conveyors
Future
Present
Coal bunker
Economizer

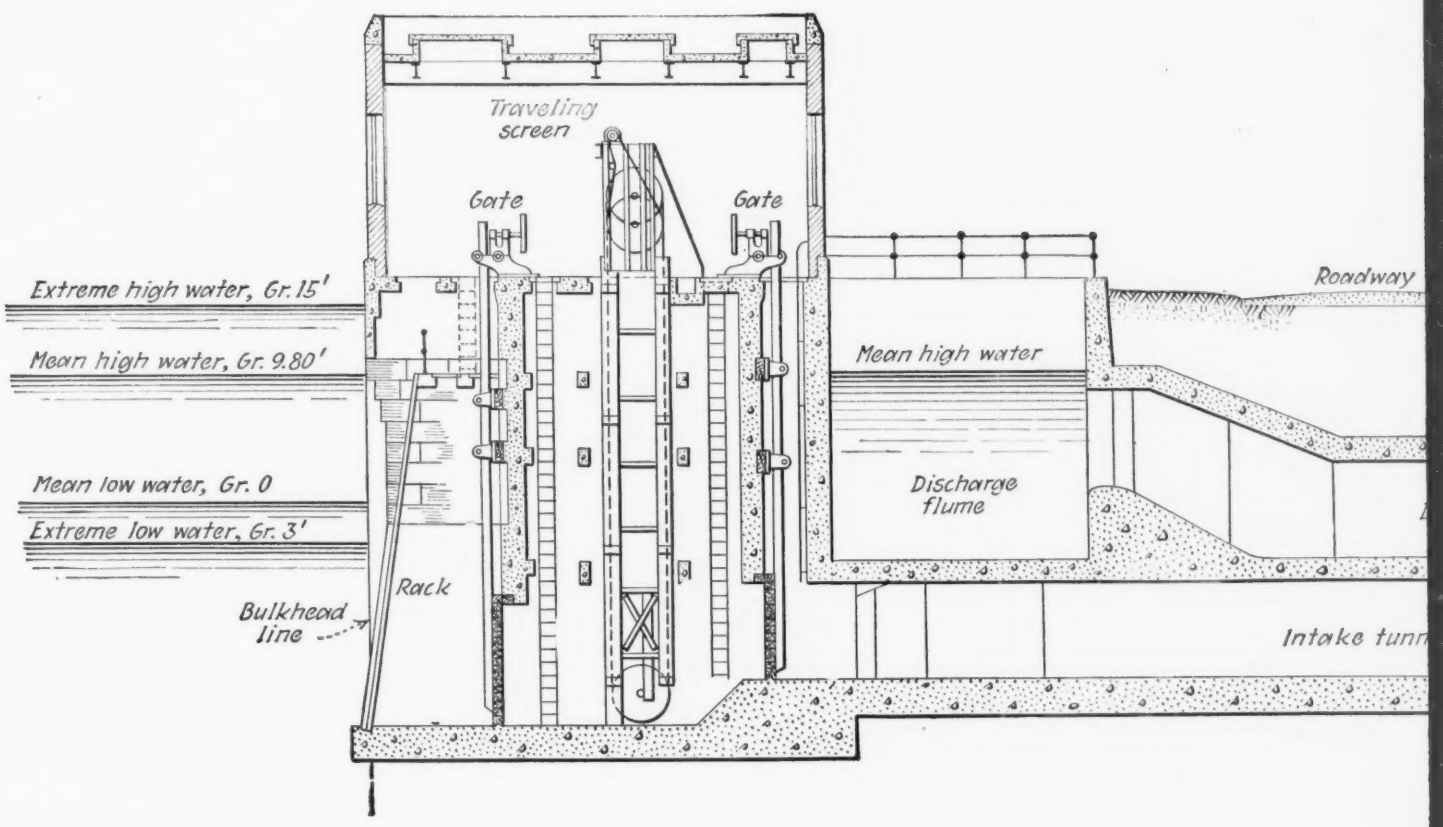
o. of Boston

Contains First 1200 Lb. Pressure Boiler and Turbine Unit.

Present Capacity (April 1925)—67,150 Kw. at 80 Per Cent Power Factor.

Ultimate Capacity 350,000 Kw.

Stone & Webster, Inc., collaborators in design and construction.

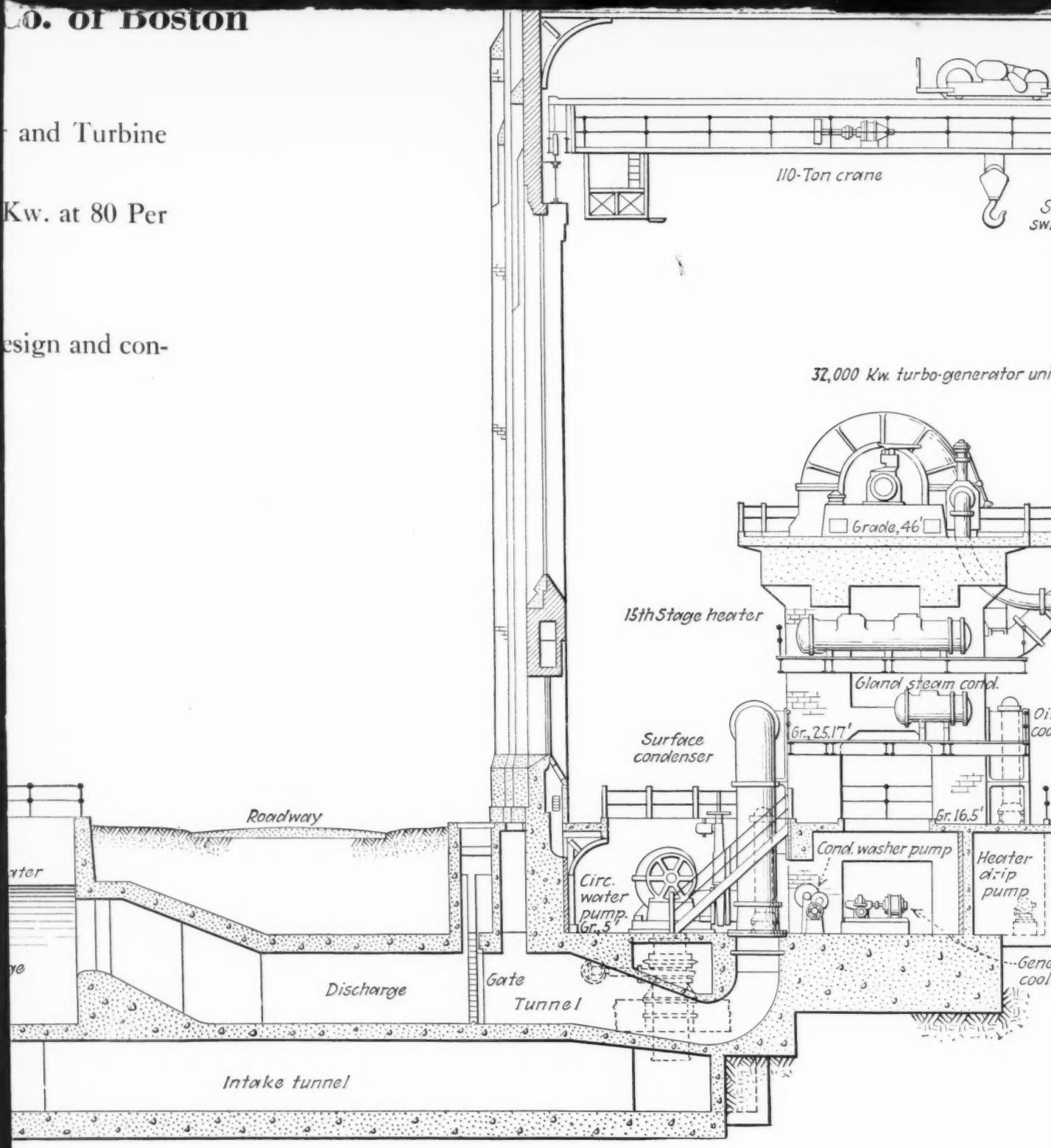


...o. of Boston

... and Turbine

... Kw. at 80 Per

...esign and con-



Battery room

Surge tank

Station service switchboard room

Grade, 73'

generator unit

20-Ton crane

High-pressure turbine

Coal spout

Main steam header

Reheater

15,732 Sq. ft., 1,200-lb. pressure boiler

Traveling platform

1,200-lb. boiler feed pump

Gage boards

Gr., 46'

19,743 Sq. ft., 350-lb. pressure boiler

Air chamber

Air chamber

Deaërator 12th stage heater

Flash tank

Pipe gallery

Ash hopper

Ash hopper

Air pump

Oil cooler

Crane

Boiler-feed pump

Evaporators

Ash gate cylinders

Boiler blowoff tank

Evaporator blowoff tank

Ash-car tracks

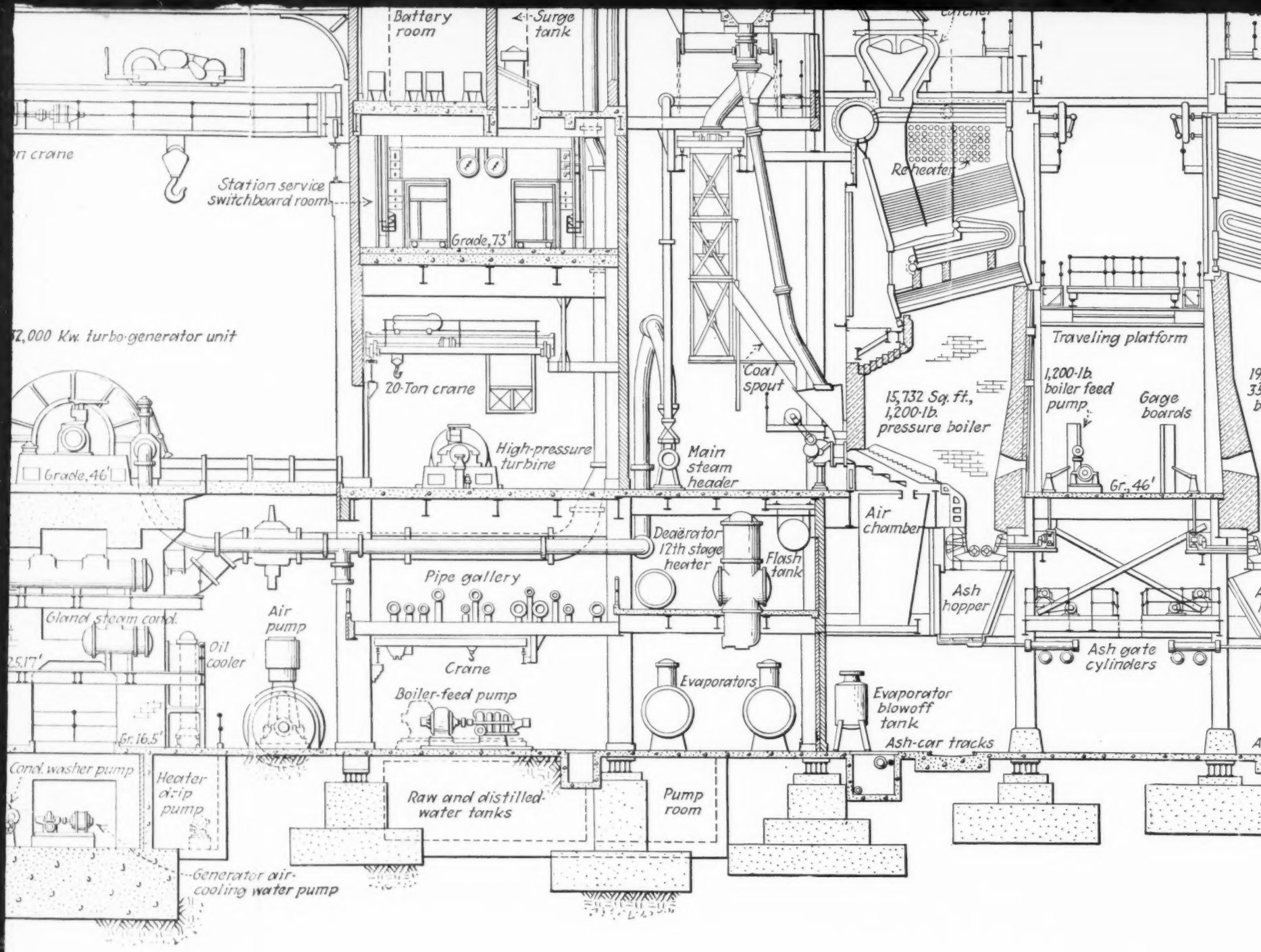
Ash-car tracks

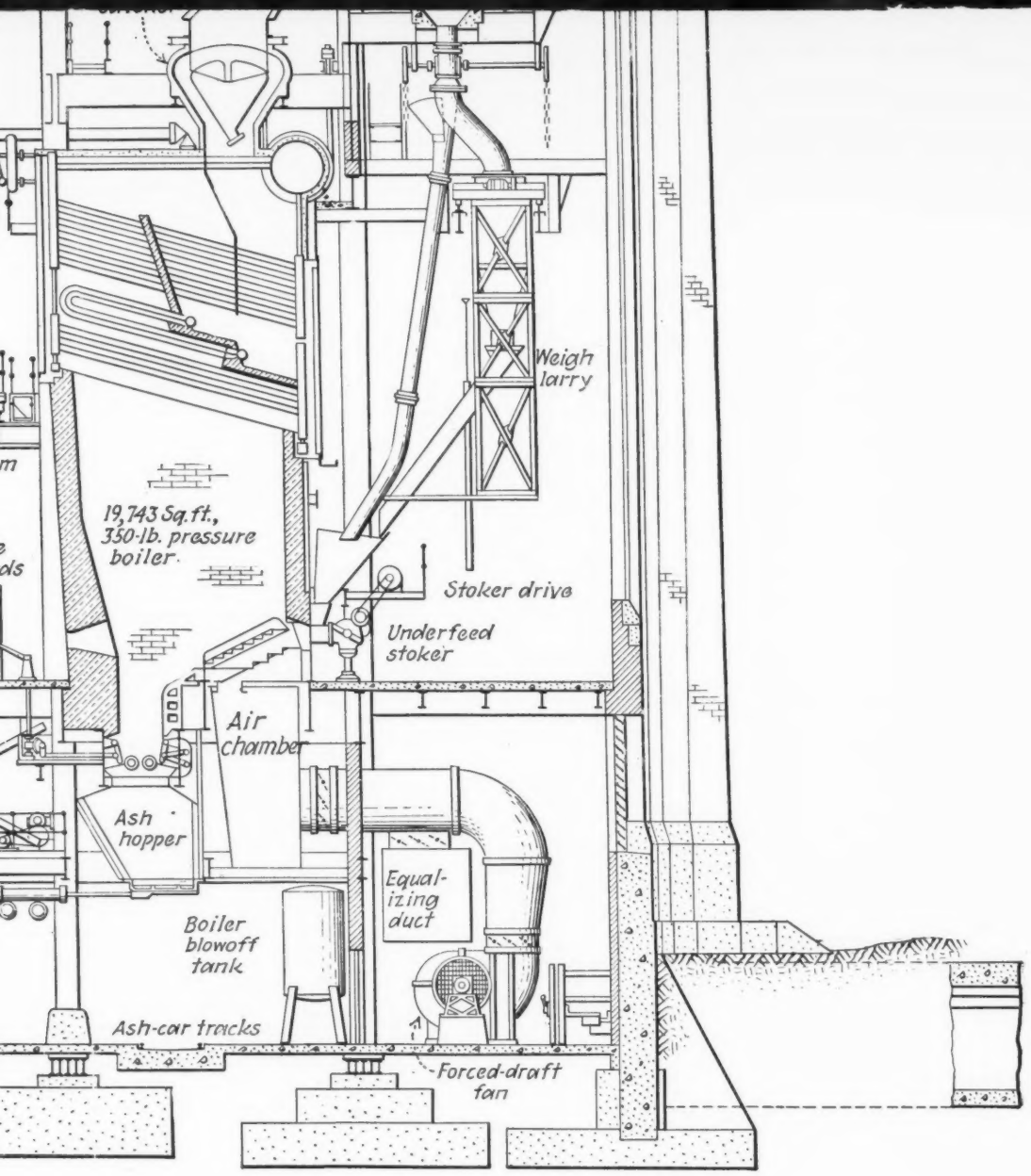
Heater drip pump

Raw and distilled-water tanks

Pump room

Generator air-cooling water pump


Battery room
Surge tank
n crane
Station service switchboard room
Grade, 73'
Reheater
72,000 Kw. turbo-generator unit
20-Ton crane
Coal spout
Traveling platform
1,200-lb. boiler feed pump
Gage boards
15,732 Sq. ft., 1,200-lb. pressure boiler
High-pressure turbine
Main steam header
Gr., 46'
Grade, 46'
Air chamber
Deaërator 12th stage heater
Flash tank
Pipe gallery
Ash hopper
Gland steam cond.
Air pump
Oil cooler
Ash gate cylinders
Crane
Evaporators
Boiler-feed pump
Evaporator blowoff tank
Gr. 16.5'
Ash-car tracks
Cond. washer pump
Heater drip pump
Raw and distilled-water tanks
Pump room
Generator air-cooling water pump


Weigh larry
19,743 Sq. ft., 350-lb. pressure boiler
Stoker drive
Underfeed stoker
Air chamber
Ash hopper
Equal-izing duct
Boiler blowoff tank
Ash-car tracks
Forced-draft fan

GENERAL

Location	On eas Weyr
Capacity present building	67,150 1,200
Capacity, ultimate	350,000
Sq.ft. total building area per kw., present	0.972
Cu.ft. total building per kw., present	96.8
Width firing aisles	22 ft.
Width operating aisle	22 ft.
Distance condenser floor to turbine-room floor	29 ft. 6
Distance turbine-room floor to crane rail	39 ft.
Distance turbine-room floor to roof truss	53 ft.
Distance boiler-room floor to roof truss	94 ft. a
Designed and built by	Stone

BOILERS AND SUPE

(Exclusive of	1,200 lb
Manufacturer	Babcoc
Type and number	3 cross
Heating surface per boiler	19,743
Furnace volume	9,850 c
Ratio heating sur. to fur. vol.	2.05 to
Arrangement of tubes	17 hig deck deck
Size of tubes, O.D.	4 in.
Boiler pressure gage	375 lb.
Type of superheater	B & W
Location	In first deck
Superheating surface per boiler	2,938 s
Ratio superheating sur. to heating surface	1.00 to
Steam temperature	707 de with
Corresponding superheat	265 de

ECONOMIZE

Manufacturer	2 Babc 1 Powe
Type	B. & W P. S.
Heating surface per economizer	B. & W
Ratio—econ. to boiler heating surface	B. & W
Soot blowers (B. & W. econ.)	Diamo 10—
Soot removal equipment (P. S. economizer only)	Water As an mon hori

FUEL

Kind (present)	New r
Ash	5—7 p
Moisture	3—4 p
Volatile hydro-carbons	19—2 60
Calorific value (dry)	14,250
Sulphur	1 per c

AIR PREHEA

Not included at

BOILER SETT

Type	Brick,

Data on Principal Equipment in Weymouth St
Edison Electric Illuminating Co. of Bos

GENERAL

.....	On east shore of Fore River at Weymouth, Mass.
g	67,150 kw. at 80 per cent p.f. (incl. 1,200 lb. unit).
.....	350,000 kw.
per kw.,	
.....	0.972
per kw.,	
.....	96.8
.....	22 ft.
.....	22 ft.
r to tub-	
.....	29 ft. 6 in.
floor to	
.....	39 ft.
floor to	
.....	53 ft.
or to roof	
.....	94 ft. approximately
.....	Stone & Webster, Inc.

RS AND SUPERHEATERS

clusive of	1,200 lb. system)
.....	Babcock & Wilcox Co.
.....	3 cross drum
ler	19,743 sq.ft.
.....	9,850 cu.ft.
. vol....	2.05 to 1
.....	17 high, 48 wide arranged in two decks with six tubes in the lower deck.
.....	4 in.
.....	375 lb. (designed for 425 lb.)
.....	B & W interdeck
.....	In first pass between lower and upper decks.
r boiler..	2,938 sq.ft.
to heating	
.....	1.00 to 6.72
.....	707 deg. F. at 200 per cent rating with 13 per cent CO_2
at.....	265 deg. F.

ECONOMIZERS

.....	2 Babcock & Wilcox Co. 1 Power Specialty Co.
.....	B. & W. hor. steel tube
.....	P. S. hor. steel tube C. I. sheathed
nomizer..	B. & W., 11,091, P. S., 12,096 sq.ft.
r heating	
.....	B. & W. 1.00 to 1.78 P.S. 1.00 to 1.63
econ.)...	Diamond Power Spec. Corp. 150 lb. 10—2 in. steel units per econ.
nt (P. S.	
.....	Water washing by fixed spray pipes. As an auxiliary 6—2 in. steel Diamond Power Specialty units set in horizontal position are used

FUEL

.....	New river bituminous
.....	5—7 per cent
.....	3—4 per cent
.....	19—22 per cent
.....	14,250—14,800 B.t.u.
.....	1 per cent

AIR PREHEATER

Not included at present

BOILER SETTINGS

.....	Brick, insulated and steel encased

Speeds	
Hoist	250 ft. per min.
Trolley travel.....	850 ft. per min.
Bridge.....	50 ft. per min.
Conveying eqp. to breaker plant..	Belt conveyors
No. of conveyors.....	1 present, 2 future
Builder.....	Robins Conveying Belt Co.
Coal Breaker Equipment	
Type.....	Bradford (Penn. Crusher Co.)
Capacity.....	440 tons per hr.
Conveying eqpt. to power sta. bunkers.....	Robins belt conveyors
Capacity.....	400 tons per hour
"B" conveyor.....	Breaker plant to transfer point
Number.....	1 present, 2 future
"C" conveyor.....	Transfer point to power station
Number.....	1 present, 2 future
"E" and "F" conveyors.....	Over power station bunkers
Number.....	1 present, 2 future
"D" conveyor.....	Cross-connection betw. "E" and "F"
Power sta. bunkers to stokers...	Fixed spouts and larries
Bunker coal gates per boiler....	6
Manufacturer.....	Henry Pratt Co.
Coal larries.....	2 (one per firing aisle)
Manufacturer.....	Colwell & McMullen
Capacity.....	6 tons
Drive.....	By motor
Speed of travel.....	50 ft. per minute
Horse power of motor.....	7½

COAL-BURNING EQUIPMENT

Type of equipment.....	Taylor Stoker (American Eng. Co.)
Number per boiler.....	One, 16 retort
Actual effective grate area.....	423.5 sq.ft.
Projected area.....	374.4 sq.ft.
Motors per stoker.....	Four 5 hp.
Speed.....	1,650 r.p.m. to 550 r.p.m.
Clinker grinder motors per stoker	Two 3 hp.
Speed.....	900

FORCED-DRAFT FANS

Maker	B.F. Sturtevant Co. turbovane
Driven by.....	135 hp. 2,200-volt G. E. motors
Number per boiler.....	1
Capacity each.....	80,000 c.f.m. @ 6 in. water press.
R.p.m.....	1,170

INDUCED-DRAFT FANS

Maker	B. F. Sturtevant, No. 120 S.S.V
Driven by.....	One 225-hp. 2,200-volt, 900-r.p.m. G. E. motor and one 100-hp. 2,200-volt 600-r.p.m. G. E. motor
Number per boiler.....	1
Capacity each.....	150,000 c.f.m. at 6 in. water press.
R.p.m.....	870

BOILER-FEED PUMPS

Makers.....	Worthington Pump & Machy. Corp.
Number and type.....	Four 6-in., 4-stage Jeanesville
Capacity.....	800 g.p.m.
3 driven by.....	300-hp. 2,200-volt motors
1 driven by.....	300-hp. West. steam turbine

DEAËRATOR PUMPS

Maker	Worthington Pump & Machy. Corp.
Number.....	Four 6-in., 2-stage
Capacity each.....	800 g.p.m. 135 ft. head
Driven by.....	40-hp. 2,200-volt G. E. motor

EXTRACTION HEATERS

Makers.....	Alberger Heater Co.
Type.....	Straight tube, floating head, closed type

HEATERS

	L. P. Extraction	Gland Steam (b)	H. P. Extraction
Surface, sq.ft.	2,000	460	2,000

AIR-REMOVAL EQUIPMENT

Type.....	Two vert. recip. pump
Capacity, each.....	1,060 c.f.m.
Driven by.....	60-hp. synchronous motors

GENERATOR AIR COOLERS

Maker and type.....	Gen. Elec. Co. surface type	
	30,000 kw. Gen. Cooler	2,000 kw. Gen. Cooler
Capacity.....	90,000 c.f.m.	10,000 c.f.m.
Cooling surface (sq.ft.).....	17,680	2,210
Cooling water.....	Condensate main salt aux.	Condensate main salt aux.

DEAËRATORS

Maker.....	Griscom-Russel Co.
Number and type.....	2 Contraflo
Steam pressure.....	14.1 lb. to 26.2 lb abs. (Extracted from 12th stage of turbine)
Capacity (lb. per hr.).....	382,000 (max.)
Water temperature.....	164 deg. F. inlet to 189 deg. F. outlet (approx.)

EVAPORATORS

Maker.....	One Griscom-Russell Co.
Type.....	Three effect, high-heat level
Capacity (lb. per hr.).....	25,000

AIR COMPRESSOR

Maker.....	Ingersoll-Rand Co.
Type.....	Cross compound
Capacity.....	520 c.f.m. free air
Driven by.....	105 hp. syn. G. E. motor

EXCITERS

Motor Driven:	
Maker and number.....	Three G. E. Co.
Capacity.....	2—200 kw., 1—250 kw.
R.p.m.....	1,200
Turbine Driven:	
Makers.....	G. E. Co.
Capacity.....	250 kw.
R.p.m.....	1,800
Voltage.....	250

TRAVELING CRANES

Turbine-Room Crane:	
Maker.....	Niles-Bement-Pond Co.
Type.....	4 motor
Capacity.....	Main hoist, 110 tons, aux. hoist 15 tons
Auxiliary Bay Crane:	
Maker.....	Niles-Bement-Pond Co.
Type.....	3-motor
Capacity.....	20 tons
Auxiliary Bay Crane:	
Maker.....	Niles-Bement-Pond Co.
Type.....	One motor
Capacity.....	5 tons

SERVICE ELEVATORS

Make.....	All Otis Elevator Co.
Switchhouse Pass. Elev.....	Push button controlled (2,000 lb.)
Speed.....	300 f.p.m.
Office Bay Elev.....	Push button controlled (2,250 lb.)
Speed.....	200 f.p.m.
Boiler Room Elevator.....	Push buttom controlled (4,000 lb.)
Speed.....	100 f.p.m.
Switchhouse Freight Elevator:	
Type.....	Car switch controlled (8,000 lb.)
Capacity.....	8,000 lb.

Raw Fresh Water Outside R voir (Storage):	
Number.....	
Capacity.....	
Raw Fresh Water Tank (Sto	
Number.....	
Capacity.....	
Raw Fresh Water Service T	
Number.....	
Capacity.....	
Made by.....	
Constructed of.....	
Distilled Water Tank (Stora	
Number.....	
Capacity.....	
Surge Tank:	
Number.....	
Capacity.....	
Made by.....	
Hot Raw-Water Return Ta	
Number.....	
Capacity.....	
Salt Water Tank (Storage):	
Number.....	
Capacity.....	
Made by.....	

PI

Circulating Water System:	
Piping and fittings..	
Valves.....	
Expansion joints (rubber	
Expansion joints (copper	
Motor-driven valve cont	
400-Lb. Steam System:	
Gate valves.....	
Globe valves..	
Boiler non-return valves	
Pipe.....	
Fittings.....	
Holly Drip System.....	
Motor-driven valve cont	
400-Lb. Boiler Feed Syste	
Gate valves.....	
Globe valves.....	
Check valves.....	
Pipe.....	
Fittings.....	
Low-Pressure Steam and W	
Gate valves...	
Check valves...	
Pipe and fittings....	
Copper expansion joints	
Atmospheric Relief Syste	
Valves.....	
Cast pipe and fittings..	
Steel pipe.....	
Bleeder Lines:	
Reverse flow valves..	
Bolts and Gaskets:	
400-lb. steam	
Studs "Mayari" steel	
Joints welded	
High-press. hot water a press. steam Gaskets— asbestos (Goodyearite	
Low press. hot and cold Gaskets—Rubber..	
Miscellaneous Valves:	
Reducing valves....	
Bronze globe valves....	
Pipe Covering:	
Covering for 700 deg. F. piping.....	
Covering, low temp. steam water systems.....	

Data on Principal Equipment in W
Edison Electric Illuminati

GENERAL

Location	On east shore of Fore River at Weymouth, Mass.
Capacity present building	67,150 kw. at 80 per cent p.f. (incl. 1,200 lb. unit).
Capacity, ultimate	350,000 kw.
Sq.ft. total building area per kw., present	0.972
Cu.ft. total building per kw., present	96.8
Width firing aisles	22 ft.
Width operating aisle	22 ft.
Distance condenser floor to turbine-room floor	29 ft. 6 in.
Distance turbine-room floor to crane rail	39 ft.
Distance turbine-room floor to roof truss	53 ft.
Distance boiler-room floor to roof truss	94 ft. approximately
Designed and built by	Stone & Webster, Inc.

BOILERS AND SUPERHEATERS

	(Exclusive of 1,200 lb. system)
Manufacturer	Babcock & Wilcox Co.
Type and number	3 cross drum
Heating surface per boiler	19,743 sq.ft.
Furnace volume	9,850 cu.ft.
Ratio heating sur. to fur. vol.	2.05 to 1
Arrangement of tubes	17 high, 48 wide arranged in two decks with six tubes in the lower deck.
Size of tubes, O.D.	4 in.
Boiler pressure gage	375 lb. (designed for 425 lb.)
Type of superheater	B & W interdeck
Location	In first pass between lower and upper decks.
Superheating surface per boiler	2,938 sq.ft.
Ratio superheating sur. to heating surface	1.00 to 6.72
Steam temperature	707 deg. F. at 200 per cent rating with 13 per cent CO_2
Corresponding superheat	265 deg. F.

ECONOMIZERS

Manufacturer	2 Babcock & Wilcox Co. 1 Power Specialty Co.
Type	B. & W. hor. steel tube P. S. hor. steel tube C. I. sheathed
Heating surface per economizer	B. & W., 11,091, P. S., 12,096 sq.ft.
Ratio econ. to boiler heating surface	B. & W. 1.00 to 1.78 P.S. 1.00 to 1.63
Soot blowers (B. & W. econ.)	Diamond Power Spec. Corp. 150 lb. 10—2 in. steel units per econ.
Soot removal equipment (P. S. economizer only)	Water washing by fixed spray pipes. As an auxiliary 6—2 in. steel Diamond Power Specialty units set in horizontal position are used

FUEL

Kind (present)	New river bituminous
Ash	5—7 per cent
Moisture	3—4 per cent
Volatile hydro-carbons	19—22 per cent
[illegible]	[illegible]
Calorific value (dry)	14,250—14,800 B.t.u.
Sulphur	1 per cent

AIR PREHEATER

Not included at present

BOILER SETTINGS

Speeds	
Hoist	250 ft. per min.
Trolley travel	850 ft. per min.
Bridge	50 ft. per min.
Conveying eqp. to breaker plant	Belt conveyors
No. of conveyors	1 present, 2 future
Builder	Robins Conveying Belt Co.
Coal Breaker Equipment	
Type	Bradford (Penn. Crusher Co.)
Capacity	440 tons per hr.
Conveying eqpt. to power sta. bunkers	Robins belt conveyors
Capacity	400 tons per hour
"B" conveyor	Breaker plant to transfer point
Number	1 present, 2 future
"C" conveyor	Transfer point to power station
Number	1 present, 2 future
"E" and "F" conveyors	Over power station bunkers
Number	1 present, 2 future
"D" conveyor	Cross-connection betw. "E" and "F"
Power sta. bunkers to stokers	Fixed spouts and larries
Bunker coal gates per boiler	6
Manufacturer	Henry Pratt Co.
Coal larries	2 (one per firing aisle)
Manufacturer	Colwell & McMullen
Capacity	6 tons
Drive	By motor
Speed of travel	50 ft. per minute
Horse power of motor	7½

COAL-BURNING EQUIPMENT

Type of equipment	Taylor Stoker (American Eng. Co.)
Number per boiler	One, 16 retort
Actual effective grate area	423.5 sq.ft.
Projected area	374.4 sq.ft.
Motors per stoker	Four 5 hp.
Speed	1,650 r.p.m. to 550 r.p.m.
Clinker grinder motors per stoker	Two 3 hp.
Speed	900

FORCED-DRAFT FANS

Maker	B.F. Sturtevant Co. turbovane
Driven by	135 hp. 2,200-volt G. E. motors
Number per boiler	1
Capacity each	80,000 c.f.m. @ 6 in. water press.
R.p.m.	1,170

INDUCED-DRAFT FANS

Maker	B. F. Sturtevant, No. 120 S.S.V
Driven by	One 225-hp. 2,200-volt, 900-r.p.m. G. E. motor and one 100-hp. 2,200-volt 600-r.p.m. G. E. motor
Number per boiler	1
Capacity each	150,000 c.f.m. at 6 in. water press.
R.p.m.	870

BOILER-FEED PUMPS

Makers	Worthington Pump & Machy. Corp.
Number and type	Four 6-in., 4-stage Jeanesville
Capacity	800 g.p.m.
3 driven by	300-hp. 2,200-volt motors
1 driven by	300-hp. West. steam turbine

DEAËRATOR PUMPS

Maker	Worthington Pump & Machy. Corp.
Number	Four 6-in., 2-stage
Capacity each	800 g.p.m. 135 ft. head
Driven by	40-hp. 2,200-volt G. E. motor

EXTRACTION HEATERS

Makers	Alberger Heater Co.
Type	Straight tube, floating head, closed type

HEATERS

	L. P.	Gland	H. P.

AIR-REMOVAL EQUIPMENT

Type	Two vert. recip. pump
Capacity, each	1,060 c.f.m.
Driven by	60-hp. synchronous mot

GENERATOR AIR COOLERS

Maker and type	Gen. Elec. Co. surface t	
	30,000 kw. Gen. Cooler	2,0
Capacity	90,000 c.f.m.	10,0
Cooling surface (sq.ft.)	17,680	2,2
Cooling water	Condensate main salt aux.	Cor s

DEAËRATORS

Maker	Griscom-Russel Co.
Number and type	2 Contraflo
Steam pressure	14.1 lb. to 26.2 lb ab from 12th stage of t
Capacity (lb. per hr.)	382,000 (max.)
Water temperature	164 deg. F. inlet to 189 (approx.)

EVAPORATORS

Maker	One Griscom-Russell C
Type	Three effect, high-heat
Capacity (lb. per hr.)	25,000

AIR COMPRESSOR

Maker	Ingersoll-Rand Co.
Type	Cross compound
Capacity	520 c.f.m. free air
Driven by	105 hp. syn. G. E. mo

EXCITERS

Motor Driven:	
Maker and number	Three G. E. Co.
Capacity	2—200 kw., 1—250 kv
R.p.m.	1,200
Turbine Driven:	
Makers	G. E. Co.
Capacity	250 kw.
R.p.m.	1,800
Voltage	250

TRAVELING CRANES

Turbine-Room Crane:	
Maker	Niles-Bement-Pond C
Type	4 motor
Capacity	Main hoist, 110 to 15 tons
Auxiliary Bay Crane:	
Maker	Niles-Bement-Pond C
Type	3-motor
Capacity	20 tons
Auxiliary Bay Crane:	
Maker	Niles-Bement-Pond C
Type	One motor
Capacity	5 tons

SERVICE ELEVATORS

Make	All Otis Elevator Co.
Switchhouse Pass. Elev.	Push button controlle
Speed	300 f.p.m.
Office Bay Elev.	Push button controlle
Speed	200 f.p.m.
Boiler Room Elevator	Push button control
Speed	100 f.p.m.
Switchhouse Freight Elevator:	
Type	Car switch controlled
Capacity	8,000 lb.

in Weymouth Station of the
nating Co. of Boston

UIPMENT

ert. recip. pump
.f.m.
synchronous motors

COOLERS

Elec. Co. surface type
0 kw. Gen. 2,000 kw. Gen.
Cooler Cooler
c.f.m. 10,000 c.f.m.
2,210
nsate main Condensate main
aux. salt aux.

ORS

m-Russel Co.
traflo
lb. to 26.2 lb abs. (Extracted
n 12th stage of turbine)
00 (max.)
eg. F. inlet to 189 deg. F. outlet
prox.)

ORS

Griscom-Russell Co.
effect, high-heat level
0

ESSOR

rsoll-Rand Co.
compound
.f.m. free air
p. syn. G. E. motor

RS

e G. E. Co.
00 kw., 1—250 kw.
0

. Co.
kw.
)

CRANES

s-Bement-Pond Co.
otor
n hoist, 110 tons, aux. hoist
tons

s-Bement-Pond Co.
otor
ons

s-Bement-Pond Co.
motor
ns

VATORS

Otis Elevator Co.
button controlled (2,000 lb.)
f.p.m.
h button controlled (2,250 lb.)
f.p.m.
a buttom controlled (4,000 lb.)
f.p.m.

switch c trolled (8,000 lb.)
0 lb.

TANKS

Raw Fresh Water Outside Reservoir (Storage):	
Number	1 present, 2 future (concrete)
Capacity	220,000 gal.
Raw Fresh Water Tank (Storage):	
Number	1 concrete under main floor
Capacity	34,000 gal.
Raw Fresh Water Service Tank:	
Number	One steel plate, boiler house roof
Capacity	15,000 gal.
Made by	James Russell Boiler Works
Constructed of	steel plate
Distilled Water Tank (Storage):	
Number	1 concrete under main floor
Capacity	22,000 gal.
Surge Tank:	
Number	1 steel plate, top floor aux. bay
Capacity	15,000 gal.
Made by	James Russell Boiler Works
Hot Raw-Water Return Tank:	
Number	1 concrete under main floor
Capacity	4,000 gal.
Salt Water Tank (Storage):	
Number	1 cast iron, top floor, boiler house
Capacity	7,000 gal.
Made by	Cochrane Corp.

PIPING SYSTEMS

Circulating Water System:	
Piping and fittings	Lumsden & Van Stone Co.
Valves	Pittsburgh Valve, Fdry. & Const. Co. Chapman Valve Mfg. Co.
Expansion joints (rubber)	U. S. Rubber Co.
Expansion joints (copper)	Lumsden & Van Stone Co.
Motor-driven valve control	Payne Dean Ltd.
400-Lb. Steam System:	
Gate valves	Schutte & Koerting Co. Pittsburgh Valve, Fdry. & Const. Co. Chapman Valve Mfg. Co.
Globe valves	Schutte & Koerting Co.
Boiler non-return valves	Schutte & Koerting Co.
Pipe	Lumsden & Van Stone Co.
Fittings	Lumsden & Van Stone Co.
Holly Drip System	Russell B. Hobson
Motor-driven valve control	Payne Dean Ltd.
400-Lb. Boiler Feed System:	
Gate valves	Schutte & Koerting Co.
Globe valves	Schutte & Koerting Co.
Check valves	Schutte & Koerting Co.
Pipe	Pittsburgh Valve, Fdry. & Const. Co.
Fittings	Pittsburgh Valve, Fdry. & Const. Co.
Low-Pressure Steam and Water Systems:	
Gate valves	Chapman Valve Mfg. Co.
Check valves	Chapman Valve Mfg. Co.
Pipe and fittings	Lumsden & Van Stone Co. Walworth Mfg. Co.
Copper expansion joints	E. B. Badger & Sons Co.
Atmospheric Relief System:	
Valves	Schutte & Koerting Co.
Cast pipe and fittings	Lumsden & Van Stone Co.
Steel pipe	Steore Engineering Co.
Bleeder Lines:	
Reverse flow valves	Atwood & Morrill
Bolts and Gaskets:	
400-lb. steam	
Studs "Mayari" steel	Bethlehem Steel Co.
Joints welded	Sargol
High-press. hot water and low press. steam Gaskets—Comp. asbestos (Goodyearite)	
Low press. hot and cold water Gaskets—Rubber	
Miscellaneous Valves:	
Reducing valves	Mason Regulator Co.
Bronze globe valves	Star Brass Mfg. Co.
Pipe Covering:	
Covering for 700 deg. F. steam piping	Lotz Asbestos Co. Covering consists of inner layer of Johns-Manville high tem. com-

Battery Charging Set:	
Type	Motor driven
Maker	Gen. Elec. Co.
Capacity	10 kw.
R.p.m.	1,800

FRESH WATER SUPPLY SYSTEM

Source of supply	Town of Weymouth
No. of connections to mains	2. One connects to 220,000 ga side reservoir and direct to gal. storage tank through valve and also directly to supply piping system in st The other connection is in main fire protection system cross connects into the s system for power and do service.

COMBUSTION CONTROL SYSTEM

Maker	Bailey Meter Co.
Type	Full automatic with selective n or combination. (Steamflow,a principle)
Panel boards	One for each boiler and on master control

BOILERS AND SUPERHEATERS (1,200 Lb. System)

Manufacturer	Babcock & Wilcox Co.
Type	One wrought steel, inclined cross-drum
Heating surface of boiler	15,732 sq.ft.
Furnace volume	7,121 cu. ft.
Ratio, heating sur. to fur. vol.	2.21
Arrangement of tubes	80 wide, 22 high, 7 tubes in deck, 15 tubes in upper deck
Size of tubes	1,760 2 in.; 80, 3½ in.
Gage of tubes	2 in. tubes No. 5 gage, 3½ in. $\frac{5}{16}$ in.
Boiler press.	1,200 lb. gage
Type of superheater	B. & W. interdeck
Superheating surface	2,923 sq.ft.
Ratio superheating to boiler heating sur.	1 to 5.38
Steam temperature	707 deg. F. at 250 per cent rat
Corresponding superheat	159 deg. F.
Type of reheater	B. & W.
Location	Above tubes, between first second passes
Reheater surface	5,938 sq.ft.
Ratio reheater to boiler sur.	1 to 2.65
Steam press.	360 lb. gage
Steam temperature	701 deg. F. at 250 per cent rat
Corresponding superheat	263 deg. F.
Economizer:	
Type	One B. & W. hor. steel tube
Flow of gas and water	Countercurrent
Heating surface sq.ft.	11,091
Ratio econ. to boiler heating sur.	1 to 1.42
Soot blowers	Diamond valve in head opera steam from reheater ro through orific to 150 lb.
Boiler Setting:	
Floor to center line of mud drum	19 ft. 8 in.
Floor to center line of steam drum	41 ft. 6 in.
Miscellaneous boiler fittings:	
Safety valves	Consolidated
Feed stop and duck valves	Edwards
Angle type blow-off valves	Nolan
Soot blowers	Diamond valve-in-head

COAL-BURNING EQUIPMENT (1200 Lb. System)

Type of equipment	Taylor stokers
Manufacturer	American Eng. Co.
Number per boiler	1
Number of retorts	15

Not included at present

BOILER SETTINGS

HEATERS

type	L. P.	Gland	H. P.

Boiler Room Elevator: 100 f.p.m.
Speed
Switchhouse Freight Elevator: Car switch c[illegible]trolled (8
Type
Capacity 8,000 lb.

arging Set:

	Motor driven
	Gen. Elec. Co.
	10 kw.
	1,800

FRESH WATER SUPPLY SYSTEM

upply	Town of Weymouth
nections to mains	2. One connects to 220,000 gal. outside reservoir and direct to 34,000 gal. storage tank through float valve and also directly to main supply piping system in sation. The other connection is into the main fire protection system which cross connects into the supply system for power and donestic service.

COMBUSTION CONTROL SYSTEM

	Bailey Meter Co.
	Full automatic with selective nanual or combination. (Steamflow,airflow principle)
ls	One for each boiler and one for master control

ERS AND SUPERHEATERS (1,200 Lb. System)

rer	Babcock & Wilcox Co.
	One wrought steel, inclined header cross-drum
rface of boiler	15,732 sq.ft.
lume	7,121 cu. ft.
ng sur. to fur. vol.	2.21
nt of tubes	80 wide, 22 high, 7 tubes in lower deck, 15 tubes in upper deck.
s	1,760 2 in., 80, 3¼ in.
es	2 in. tubes No. 5 gage, 3¼ in. tubes $\frac{5}{16}$ in.
	1,200 lb. gage
erheater	B. & W. interdeck
g surface	2,923 sq.ft.
heating to boiler heat-	1 to 5.38
erature	707 deg. F. at 250 per cent rating
ng superheat	159 deg. F.
eater	B. & W.
	Above tubes, between first and second passes
rface	5,938 sq.ft.
ter to boiler sur	1 to 2.65
	360 lb. gage
erature	701 deg. F. at 250 per cent rating
ng superheat	263 deg. F.
:	
	One B. & W. hor. steel tube
as and water	Countercurrent
urface sq.ft.	11,091
n. to boiler heating sur.	1 to 1.42
ers	Diamond valve in head operated by steam from reheater reduced through orifie to 150 lb.
ng:	
nter line of mud drum	19 ft. 8 in.
center line of steam	41 ft. 6 in.
ns boiler fittings:	
lves	Consolidated
and duck valves	Edwards
e blow-off valves	Nolan
ers	Diamond valve-in-head

L-BURNING EQUIPMENT (1200 Lb. System)

pment	Taylor stokers
r	American Eng. Co.
boiler	1
ctors	15

Calorific value (dry)
Sulphur

) f.p.m.

switch c ntrolled (8,000 lb.)
0 lb.

Pipe Covering:
Covering for 700 deg. F. steam piping

Lotz Asbestos Co.
Covering consists of inner layer of Johns-Manville high tem. com-

COAL-BURNING EQUIPMENT (Taylor Stoker System)

Type of equipment ..... Taylor stokers
Manufacturer ..... American Eng. Co.
Number per boiler 1
Number of retorts 15

ue (dry) ..... 14,250 - 14,800 B.t.u.

Driven by ..... 40-hp. 2,200-volt G. E. motor

SERVICE ELEVATORS

high-press. low-press. steam)

Boiler 1
Reports 15

Calorific value (dry) .....
Sulphur .....

AI
Not i

BOI

Type .....

Construction of setting fur.

Materials furnished by Be
Furnace Appliance Co.,
borundum Co., General
fractories Co., Geo. All
Son Co., Portland Stone
Co. and Babcock & Wilco

MISCELLAN

Safety valves .....
Feed stop and check valves
Straightway blow-off valves
Angle blow-off valves .....
Dusting hose connection ...
Soot blowers .....
Gage glasses .....
Water columns .....

Type .....

Built by .....
Boilers per stack .....
Diameter (at top) .....
Height, stack column .....

COAL STORAGE

Supply received by .....
Outside storage capacity ...

Station bunker capacity ...
Length of unloading wharf
Type of boat-unloading e
ment .....

Builder .....
Capacity of towers (each) .
Power supply for motors ..
Feeder and shuttle belt conv
manufactured by .....
Feeder belt conveyor
Speed .....
Belt manufactured by .....
Shuttle belt conveyor
Speed .....
Stocking and reclaiming eq

Builder .....
Cap. of bridge stocking a
claiming .....
Stocking belt conveyor
Manufacturer .....
Speed .....
Belt manufactured by ...
Reclaiming grab bucket
Capacity .....
Cap. receiving hopper .....
Feed from receiving hoppe

Driven by ..... 40-hp. 2,200-volt G. E. motor

SERVICE ELEVATORS

Make ..... All-Otis Elevator Co.

high-press. hot water and low press. steam Gaskets—Comp. asbestos (Goodyearite) .....

ue (dry)	14,250—14,800 B.t.u.
	1 per cent

AIR PREHEATER

Not included at present

BOILER SETTINGS

	Brick, insulated and steel encased and ventilated side, front, and rear walls at fire zone.
n of setting fur. walls	All walls solid fire-brick laid in high temperature cement in furnace and to top of first pass. Balance laid in clay. Front wall 18 in. (9 in. camber) + 4 in. insulation + ¼ in. millboard. Rear wall 18 in at top to approx. 48 in. at bottom (9 in. camber on 18 in. portion) + 4 in. insulation + ¼ in. millboard. Side walls 2 ft. 3 in + 4 in. insulation + ¼ millboard. Expansion taken care of by paper between horizontal joints in furnace. Vertical open built-in joints in all walls.
furnished by Bernitz Appliance Co., Car- n Co., General Re- Co., Geo. Allen & Portland Stone Ware Babcock & Wilcox Co.	

MISCELLANEOUS BOILER FITTINGS

es	Consolidated five 4½ in. per blr.
nd check valves	Edward two 4 in. per blr.
y blow-off valves	Nolan two 2½ in. per blr.
-off valves	Nolan two 2½ in. per blr.
se connection	Edwards one ¾ in. per blr.
rs	Diamond
rs	Ernst. inclined type, 2 per boiler.
ms	Stets., 2 per boiler

CHIMNEYS

	Two radial brick supported on building steel
	Alphons Custodis Chimney Con. Co.
stack	4
at top)	18 ft.
ck column	128 ft. 6 in.

AL STORAGE AND HANDLING EQUIPMENT

ived by	Steamer
rage capacity	107,000 tons (present) 300,000 tons (ult.)
nker capacity	3,000 tons (approx.)
unloading wharf	400 ft. (present) 1,200 ft. (uture)
oat-unloading equip-	
	Electrically operated traveling, hoisting towers
	John H. Proctor & Co.
f towers (each)	400 tons per hour
ply for motors	550 volt, 3 phase, 60 cycles
shuttle belt conveyors	
tured by	Stephens-Adamson Mfg. Co.
t conveyor	
	62 ft. per minute
factured by	Boston Belting Co.
lt conveyor	
	400—600 ft. per minute
nd reclaiming equip.	Elec. op. trav. man trolley gantry bridge
	Brown Hoisting Mach. Co.
	400 tons per hr.
belt conveyor	
cturer	Robins Conveying Belt Co.
	400 ft. per minute
nufactured by	B. F. Goodrich Co.
g grab bucket	
y	6 tons
ving hopper	40 tons
receiving hopper	Reciprocating plate feeder

Driven by	40-hp. 2,200-volt G. E. motor

EXTRACTION HEATERS

Makers	Alberger Heater Co.
Type	Straight tube, floating head, closed type

HEATERS

	L. P. Extraction	Gland Steam (b)	H. P. Extraction
Surface, sq.ft	2,000	460	2,000
Passes	4	4	4
Tube material	Admiralty	Admiralty	Admiralty
Water per hr	310,000	310,000	310,000
Temp. entering, deg. F	92	145	174
Temp. leaving, deg. F	145	164	228
Steam per hr	15,900	4,800	24,300
Abs. pressure	3.89	14.7	26.8
Heater drip	By pump to deaërator	To L. P. Extraction heater	To deaërator

MAIN TURBO-GENERATORS

Maker and number	Two General Electric Co.
Type	17-stage single-cylinder, with direct connected auxiliary generator.
Capacity	Turbine 32,000-kw.; main generator, 30,000-kw.; aux. gen., 2,000-kw.

TURBINE GUARANTEES

Guaranteed performance at 350-lb. press. 700 deg. temp., 1 in. back press. abs. No bleeding but includes gland steam leakage

Load, kw.	Lb. steam per Kw.-Hr.
16,000	10.39
24,000	9.82
30,000	9.60
32,000	9.80

MAIN GENERATORS

Kilovolt-amperes	37,500 (30,000 Kw. at 80% p f)
Characteristics	3-phase, 60-cycle, 14,000volts
Excitation	250 volts

AUXILIARY GENERATORS

Kilovolt-amperes	2,500
Characteristics	3-phase, 60-cy., 2,300 volts

SURFACE CONDENSERS

Maker and number	Two Worthington Pump & Mach. Corp.
Type	Single compartment 2-pass.
Tube surface	45,000 sq.ft. tube sheets drilled for 50,000 sq.ft.
Tube surface per kw. main turbine rating	1.41
Lb. steam per sq.ft. per hr. (no bleeding)	7
Connection to turbine	Rigid
Support	Springs
Tubes, composition	Admiralty, by cupping process
Tubes, maker	The American Brass Co.

CIRCULATING PUMPS

Number	4
Capacity, one pump running	39,000 g.p.m.
Capacity, two pumps running	60,000 g.p.m.
R.p.m.	350
Driven by	300-hp. 2,200-volt var. speed motors

CONDENSATE PUMPS

Number	4
Capacity, each	750 g.p.m.
Total head	225 ft.
Driven by	100-hp. 2,200-volt const. speed G. E. motors

SERVICE ELEVATORS

Make	All Otis Elevator Co.
Switchhouse Pass. Elev.	Push button controlled (2,000 lb.)
Speed	300 f.p.m.
Office Bay Elev	Push button controlled (2,250 lb.)
Speed	200 f.p.m.
Boiler Room Elevator	Push buttom controlled (4,000 lb.)
Speed	100 f.p.m.
Switchhouse Freight Elevator:	
Type	Car switch controlled (8,000 lb.)
Capacity	8 000 lb.

SCREEN WELL EQUIPMENT

Water Screens:	
Maker	Chain Belt Co.
Type	"Rex" traveling
Number per screen well	2 (1 only installed at present)
Sluice Gates:	
Maker	S. Morgan Smith Co.
Type	Cast iron, bronze mounted with bronze stems, hand operated
Screen Pump:	
Maker	Worthington Pump & Mch. Corp.
Type	Double-suct., single-stage cent.
Capacity	500 g.p.m.
Discharge head (ft.)	40
Driven by	10 hp., 550 v., const. speed, ind. mo

MISCELLANEOUS PUMPS

Make	All Worthington Pump & Mch. Corp. (except sump.)
Emergency Station Service	Two double-suction, single-stage motor-driven centrifugal
Capacity	800 g.p.m.
Station Service	One 2-stage centrifugal
Capacity	100 g.p.m.
Distilled Water	Two double-suction single-stage
Capacity	800 g.p.m.
Discharge head	140 ft.
Evaporator service	Two double-suction, single-stage
Capacity	80 g.p.m.
Discharge head	40 ft.
Deaërator pumps	Four 2-stage, hot-well type driven by const. speed motors
Capacity	800 g.p.m.
Heater drip pumps	Two 2-stage, hot-well type
Capacity	100 g.p.m.
Discharge head	70 ft.
Fire pump	One double-suction, single-stage
Capacity	1,500 g.p.m.
Discharge head	100 lb. gage
Driven by	150 hp. G. E. const. speed motor
Evaporator Feed Pumps:	
Type	Two triplex, spiral gear drive
Capacity	80 g.p.m.
Discharge head	205 (lb. gage)
Condenser Tube Wash Pump:	
Type	One triplex, spiral gear drive from motor.
Capacity	600 g.p.m.
Discharge head	280 lb. gage
Emergency Generator Air Cooler Pumps:	
Type	Two double-suction, single-stage motor driven
Capacity	1,200 g.p.m.
Ash Quenching and Salt Water Service:	
Type	One double-suction single-stage
Capacity	600 g.p.m.
Discharge head	158 ft.
Motor characteristics	2,200 volt const. speed
Sump Pumps:	
Maker	Three Yeoman's Bros. Co.
Type	Ver. single-suc., single-stage centrif.
Capacity	100 g.p.m.
Driven by	5 hp. Louis Allis const. speed motor
Priming System Ejectors:	
Maker	Schutte & Koerting Co.
Type	Steam ejectors
Size	3 in.
Steam conditions	350 lb. gage 700 deg. F. total temp.

high-press. wa
press. steam C
asbestos (Go
Low press. hot
Gaskets—Ru
Miscellaneous Va
Reducing valv
Bronze globe v
Pipe Covering:
Covering for 7
piping

Covering, low
water systen

Type of flange

Lubricating Oil

For main units:
Oil Coolers:
Maker
Number
Cooling water

Filters:
Maker
For General Sta
Purifier:
Maker
Type
Storage:
Maker
Tanks

Feed-Pump Pre
Motor contro

Press. regulat

Desuperheaters
Maker

Feed-Water Re
Maker
Number per
Instruments:
Venturi mete
Thermomete
Indicating
Recording
Flow meters
Tank gages

Gages:
Indicating
Recording
Draft
Load indicator

Control Batter
Maker
No. cells
No. plates p
Capacity, a
Control Batter
(Same as for
Lighting Batte
Maker
No. cells
No. plates p
Capacity, a
Exciter Batte
Maker
No. cells
No. plates p
Capacity, a

Miscellaneous Boiler Fittings:

Safety valves	Consolidated
Feed stop and duck valves	Edwards
Angle type blow-off valves	Nolan

Driven by	40-hp. 2,200-volt G. E. motor

EXTRACTION HEATERS

Makers	Alberger Heater Co.
Type	Straight tube, floating head, closed type

HEATERS

	L. P. Extraction	Gland Steam (b)	H. P. Extraction
Surface, sq.ft	2,000	460	2,000
Passes	4	4	4
Tube material	Admiralty	Admiralty	Admiralty
Water per hr	310,000	310,000	310,000
Temp. entering, deg. F	92	145	174
Temp. leaving, deg. F	145	164	228
Steam per hr	15,900	4,800	24,300
Abs. pressure	3.89	14.7	26.8
Heater drip	By pump to deaërator	To L. P. Extraction heater	To deaërator

MAIN TURBO-GENERATORS

Maker and number	Two General Electric Co.
Type	17-stage single-cylinder, with direct connected auxiliary generator.
Capacity	Turbine 32,000-kw.; main generator, 30,000-kw.; aux. gen., 2,000-kw.

TURBINE GUARANTEES

Guaranteed performance at 350-lb. press. 700 deg. temp., 1 in. back press. abs. No bleeding but includes gland steam leakage

Load, kw	Lb. steam per Kw.-Hr.
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32,000	9.80

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Kilovolt-amperes	37,500 (30,000 Kw. at 80% p.f)
Characteristics	3-phase, 60-cycle, 14,000 volts
Excitation	250 volts

AUXILIARY GENERATORS

Kilovolt-amperes	2,500
Characteristics	3-phase, 60-cy., 2,300 volts

SURFACE CONDENSERS

Maker and number	Two Worthington Pump & Mach. Corp.
Type	Single compartment 2-pass.
Tube surface	45,000 sq.ft. tube sheets drilled for 50,000 sq.ft.
Tube surface per kw. main turbine rating	1.41
Lb. steam per sq.ft. per hr. (no bleeding)	7
Connection to turbine	Rigid
Support	Springs
Tubes, composition	Admiralty, by cupping process
Tubes, maker	The American Brass Co.

CIRCULATING PUMPS

Number	4
Capacity, one pump running	39,000 g.p.m.
Capacity, two pumps running	60,000 g.p.m.
R.p.m.	550
Driven by	300-hp. 2,200-volt var. speed motors

CONDENSATE PUMPS

Number	4
Capacity, each	750 g.p.m.
Total head	225 ft.
Driven by	100-hp. 2,200-volt const. speed G. E. motors

SERVICE ELEVATORS

Make	All Otis Elevator Co.
Switchhouse Pass. Elev.	Push button controlled (2,000 lb.)
Speed	300 f.p.m.
Office Bay Elev.	Push button controlled (2,250 lb.)
Speed	200 f.p.m.
Boiler Room Elevator	Push buttom controlled (4,000 lb.)
Speed	100 f.p.m.
Switchhouse Freight Elevator:	
Type	Car switch controlled (8,000 lb.)
Capacity	8,000 lb.

SCREEN WELL EQUIPMENT

Water Screens:	
Maker	Chain Belt Co.
Type	"Rex" traveling
Number per screen well	2 (1 only installed at present)
Sluice Gates:	
Maker	S. Morgan Smith Co.
Type	Cast iron, bronze mounted with bronze stems, hand operated
Screen Pump:	
Maker	Worthington Pump & Mch. Corp.
Type	Double-suct., single-stage cent.
Capacity	500 g.p.m.
Discharge head (ft.)	40
Driven by	10 hp., 550 v., const. speed, ind. mo.

MISCELLANEOUS PUMPS

Make	All Worthington Pump & Mch. Corp. (except sump.)
Emergency Station Service	Two double-suction, single-stage motor-driven centrifugal
Capacity	800 g.p.m.
Station Service	One 2-stage centrifugal
Capacity	100 g.p.m.
Distilled Water	Two double-suction single-stage
Capacity	800 g.p.m.
Discharge head	140 ft.
Evaporator service	Two double-suction, single-stage
Capacity	80 g.p.m.
Discharge head	40 ft.
Deaerator pumps	Four 2-stage, hot-well type driven by const. speed motors
Capacity	800 g.p.m.
Heater drip pumps	Two 2-stage, hot-well type
Capacity	100 g.p.m.
Discharge head	70 ft.
Fire pump	One double-suction, single-stage
Capacity	1,500 g.p.m.
Discharge head	100 lb. gage
Driven by	150 hp. G. E. const. speed motor
Evaporator Feed Pumps:	
Type	Two triplex, spiral gear drive
Capacity	80 g.p.m.
Discharge head	205 (lb. gage)
Condenser Tube Wash Pump:	
Type	One triplex, spiral gear drive from motor.
Capacity	60 g.p.m.
Discharge head	280 lb. gage
Emergency Generator Air Cooler Pumps:	
Type	Two double-suction, single-stage motor driven
Capacity	1,200 g.p.m.
Ash Quenching and Salt Water Service:	
Type	One double-suction single-stage
Capacity	600 g.p.m.
Discharge head	158 ft.
Motor characteristics	2,200 volt const. speed
Sump Pumps:	
Maker	Three Yeoman's Bros. Co.
Type	Vert. single-suc., single-stage centrif.
Capacity	100 g.p.m.
Driven by	5 hp. Louis Allis const. speed motor
Priming System Ejectors:	
Maker	Schutte & Koerting Co.
Type	Steam ejectors
Size	3 in.
Steam conditions	350 lb. gage 700 deg. F. total temp.

High-press. hot water and low press. steam Gaskets—Comp. asbestos (Goodyearite)	
Low press. hot and cold water Gaskets—Rubber	
Miscellaneous Valves:	
Reducing valves	Mason Regulator Co.
Bronze globe valves	Star Brass Mfg. Co.
Pipe Covering:	
Covering for 700 deg. F. steam piping	Lotz Asbestos Co. Covering consists of inner Johns-Manville high te position and outer layer o
Covering, low temp. steam and water systems	Keasbey & Mattison Co. (1 throughout)
Type of flange covers	Removable

Lubricating Oil System:

For main units:	
Oil Coolers:	
Maker	Schutte & Koerting
Number	4—(2 each unit)
Cooling water	Condensate in main cooler Salt in aux. cooler
Filters:	
Maker	Two S. F. Bowser & Co. con
For General Stations Use:	
Purifier:	
Maker	One De Laval Separator C
Type	Centrifugal
Storage:	
Maker	S. F. Bowser & Co.
Tanks	1—4,000 gallon 2 compartm cipitation tank 1—2,000 gallon clean oil tan
Feed-Pump Pressure Regulators:	
Motor control by	G. E. Co. (Steam driven pu controlled)
Press. regulators by	Ruggles Klingeman Co.
Desuperheaters:	
Maker	Griscom Russell Co.—1 Elliott Company—1
Feed-Water Regulators:	
Maker	Williams Gage Co.
Number per boiler	2
Instruments:	
Venturi meters	Builders' Iron Foundry Co
Thermometers:	
Indicating	Taylor Instrument Co.
Recording	The Foxboro Co.
Flow meters	Gen. Elec. Co.
Tank gages	Gen. Elec. Co. The Foxboro Co.
Gages:	
Indicating	Star Brass Mfg. Co.
Recording	The Foxboro Co.
Draft	The Foxboro Co.
Load indicators	Gen. Elec. Co.

STORAGE BATTERIES

Control Battery Main Building:	
Maker	Electric Storage Battery C
No. cells	60
No. plates per cell	15
Capacity, amps. for 1 hr.	140
Control Battery Switchhouse: (Same as for main building)	
Lighting Battery Control Bay:	
Maker	Electric Storage Battery C
No. cells	114
No. plates per cell	15
Capacity, amps. for one hr.	140
Exciter Battery:	
Maker	Electric Storage Battery C
No. cells	140
No. plates per cell	37
Capacity, amps. for one hr.	1,350

...s boiler Fittings:	
...lves	Consolidated
...and duck valves	Edwards
...blow-off valves	Nolan
...s	Diamond valve-in-head

Miscellaneous Boiler Fittings:	
Safety valves	Consolidated
Feed stop and duck valves	Edwards
Angle type blow-off valves	Nolan
Soot blowers	Diamond valve-in-head

COAL-BURNING EQUIPMENT (1200 Lb. System)

Type of equipment	Taylor stokers
Manufacturer	American Eng. Co.
Number per boiler	1
Number of retorts	15
Actual effective grate area	429. 7 sq.ft.
Projected grate area	377. 8 sq.ft.
Motors per stoker	4-5 hp. (1,650 r.p.m.)
Forced-Draft Fan:	
Maker	B. F. Sturtevant Co.
Driven by	135 hp. 2.200 volt B. T. S. motor
Number per boiler	1
Capacity	80,000 c.f.m. at 6 in. water
Induced-Draft Fan:	
Maker	B. F. Sturtevant Co.
Driven by	1—225 hp. 2,200 volt, S. R. 900 r.p.m. G. E. motor and 1—100 hp. 2.200 volt S. R. 600 r.p.m. G. E. motor
Number per boiler	1
Capacity each	150,000 c.f.m. at 6 in. water pressure

Boiler-Feed Pumps:

Motor driven:	
Maker	Worthington Pump & Mach. Corp.
Number and capacity	One 300 g.p.m.
Type	Cent. 8-stage single-suction, hyd. bal.
Driven by	350 hp., slip ring, 3,600 r.p.m. synchronous motor
Steam driven:	
Maker	G. and J. Weir, Ltd., Bethehem Shipbuilding Corp., Agent
Number	1
Capacity	300 g.p.m.
Type	Cent. 4-stage, single suction, hyl. bal.
Driven by	Weir steam turbine, 5,400 r.p.m. single-stage for steam at 350 lb. non-condensing
Gland Steam Condenser:	
Maker	Alberger Heater Co.
Type	Multihead closed type
Used for	Heating feed water by gland leakage from 1,200 lb. turbo-generator
Surface sq.ft	584
Temp. entering deg. F	104
Temp. leaving, deg. F	139
Heater drip	To l. p. extraction heater

HIGH-PRESSURE TURBO-GENERATOR

Maker	Gen. Elec. Co.
Number	1
Type	Horiz. 20-stage impulse, four bearing, single flow, steam at throtele 1,200 lb. exhaust 360 lb.
Capacity	3,150 kw. (at 100 per cent p.f.)
Speed	3,600 r.p.m
Current Characteristics	3 phase, 60 cycles, 14,000 volts

PIPING

1,200 lb. Steam System:	
Gate valves	Schutte & Koerting Co.
Trip throttle and trip by-pass valves	Schutte & Koerting Co.
Drip valves	Schutte & Koerting Co
Pipe and fittings	Pittsburgh Valve, Fdy. & Const. Co.
Drip system	Hand operated
Motor-driven valve control	Payne Dean, Ltd.
1,200 lb.-Boiler Feed Discharge System:	
Gate and globe	Schutte & Koerting Co.
Pipe and fitting	Pittsburgh Valve, Fdy. & Const. Co.
Pressure reducing nozzle	Schutte & Koerting Co.

S Boiler Fittings:	
ves	Consolidated
and duck valves	Edwards
blow-off valves	Nolan
rs	Diamond valve-in-head

-BURNING EQUIPMENT (1200 Lb. System)

pment	Taylor stokers
r	American Eng. Co.
boiler	1
storts	15
ve grate area	429 7 sq.ft.
te area	377 8 sq.ft.
oker	4-5 hp. (1,650 r.p.m.)
Fan:	
	B. F. Sturtevant Co.
	135 hp. 2,200 volt B. T. S. motor
r boiler	1
	80,000 c.f.m. at 6 in. water
ft Fan:	
	B. F. Sturtevant Co.
	1—225 hp. 2,200 volt, S. R. 900 r.p.m. G. E. motor and 1—100 hp. 2,200 volt S. R. 600 r.p.m. G. E. motor
r boiler	1
ach	150,000 c.f.m. at 6 in. water presure

Pumps:

n:	
	Worthington Pump & Mach. Corp.
nd capacity	One 300 g.p.m.
	Cent. 8-stage single-suction, hyd. bal.
	350 hp., slip ring, 3,600 r.p.m. synchronous motor
n:	
	G. and J. Weir, Ltd., Bethlehem Shipbuilding Corp., Agent
	1
	300 g.p.m.
	Cent. 4-stage, single suction, hyd. bal.
	Weir steam turbine, 5,400 r.p.m. single-stage for steam at 350 lb. non-condensing
Condenser:	
	Alberger Heater Co.
	Multihead closed type
	Heating feed water by gland leakage from 1,200 lb. turbo-generator
	584
ing deg. F.	104
ng, deg. F.	139
	To l. p. extraction heater

HIGH-PRESSURE TURBO-GENERATOR

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PIPING

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ves	Schutte & Koerting Co.
ttle and trip by-pass	
	Schutte & Koerting Co.
ves	Schutte & Koerting Co
-fittings	Pittsburgh Valve, Fdy. & Const. Co.
em	Hand operated
iven valve control	Payne Dean, Ltd.
iler Feed Discharge System:	
l globe	Schutte & Koerting Co.
fitting	Pittsburgh Valve, Fdy. & Const. Co.
reducing nozzle	Schutte & Koerting Co.

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Some Views Within Weymouth Station

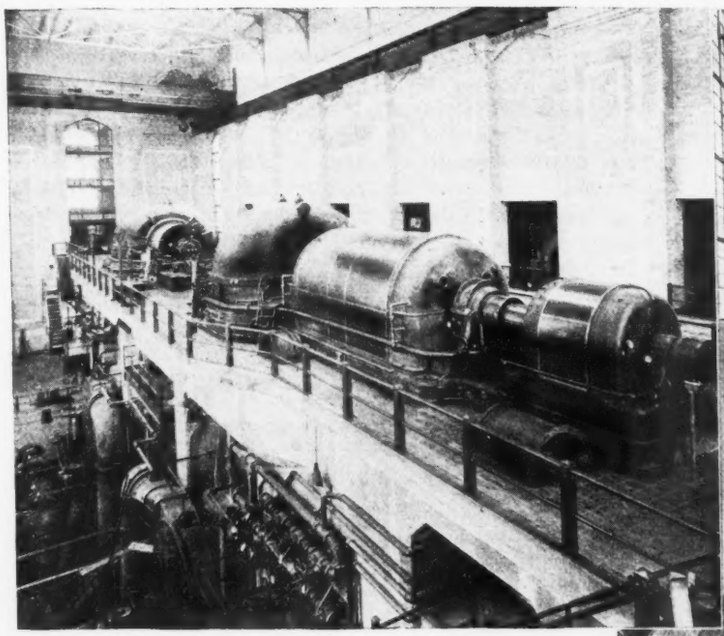

Fig. 1—Turbine operating floor looking north. Note the accessibility and light

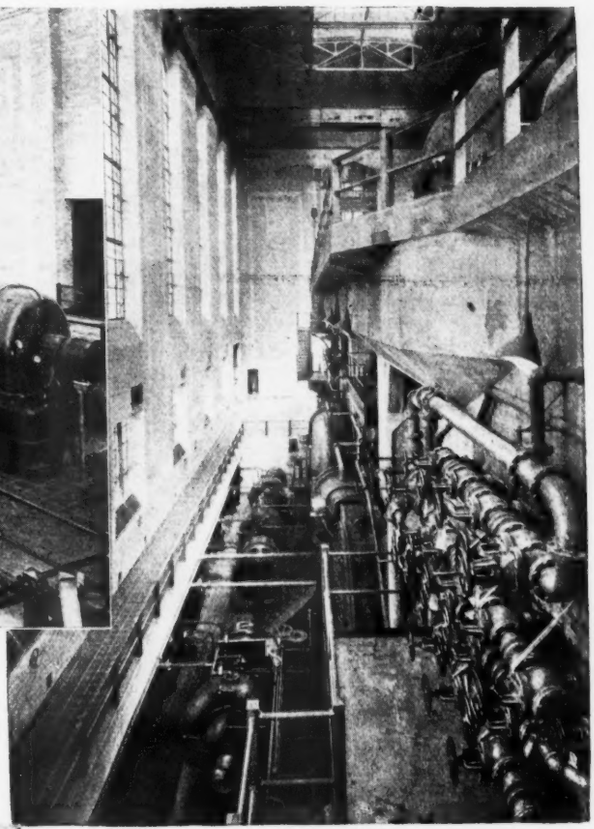

Fig. 2—Turbine auxiliaries, showing especially condensers and circulating pumps

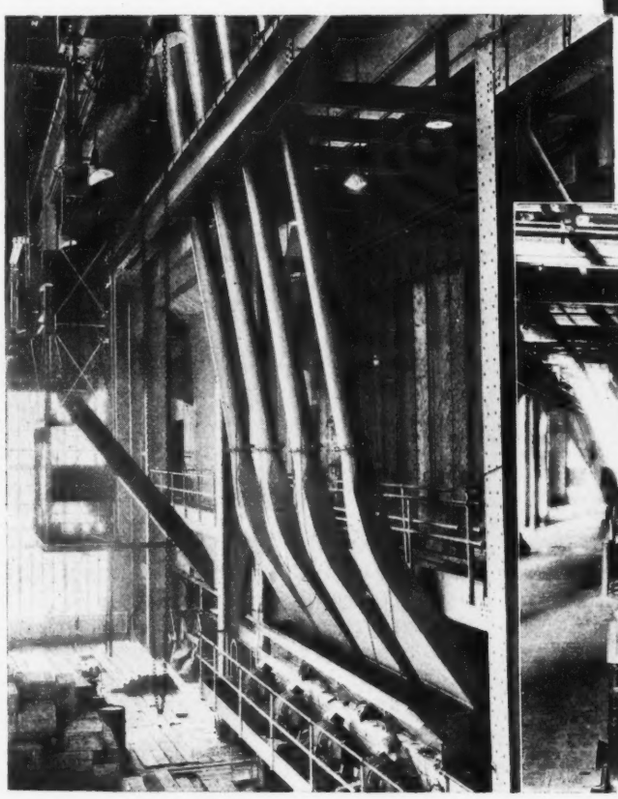

Fig. 3—Firing aisle. Larry arranged so as to clear coal chute

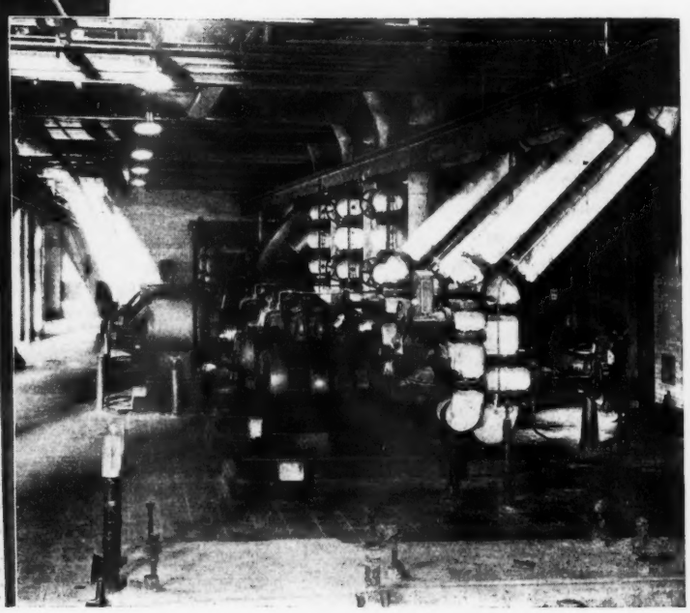

Fig. 4—Main floor auxiliary bay with pipe gallery above

The generators are kept cool by air circulating on the closed system. The heat is removed by water flowing through surface coolers. Condensate is normally used for this purpose. There are, however, groups of auxiliary cooler sections in which salt water is used. These latter sections are called upon in case the amount of condensate at low loads is not sufficient to carry away the heat, and also during periods of low vacuum when the condensate would be too high in temperature. There is no interconnection between the condensate and salt-water piping, thus preventing pollution of the former.

The closed system of ventilation reduces the fire risk in the generators and also gives an opportunity of checking an incipient fire by "flooding" the ventilation chamber with CO_2, an inert gas.

Twelve-Hundred-Pound Installation

The 1,200-lb. steam installation now being erected consists of a boiler with primary superheater and reheater, stoker and combustion equipment, a turbo-generator, boiler-feed pumps and the necessary piping material. The following short description will be supplemented in another article:

The boiler and turbine are designed to operate at a maximum steam pressure of 1,200 lb. per sq.in. The boiler generates the steam and superheats it to 700 deg. F. total temperature and then delivers it to the turbine. From the turbine the exhaust at 360 lb. returns to the reheater in the boiler, where its temperature is again raised to 700 deg. F. The steam is then delivered to the main steam header for use in the normal pressure (350 lb.) turbo-generators. The high-pressure boiler and the high-pressure turbine are operated together as a unit.

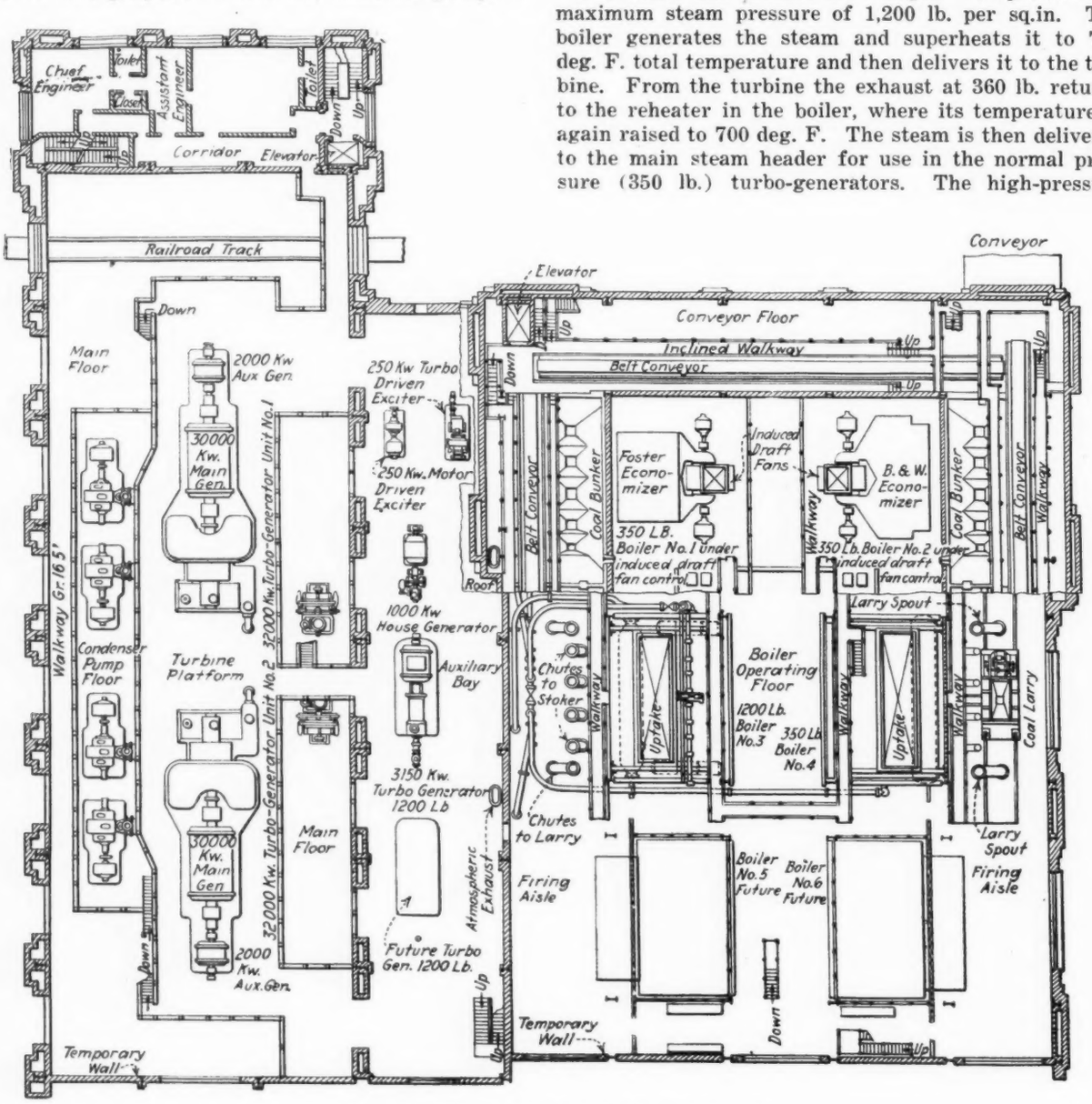

Fig. 5—Plan of turbine and boiler rooms

The 1,200-lb. steam boiler is a modification of the conventional cross-drum type, the heating surface consisting of 2-in. tubes 15 ft. long, arranged in three passes. The drum is made from a seamless steel forging 32 ft. long by 4 ft. in diameter, forged on a mandrel to give walls 4 in. thick. The boiler tubes are arranged in upper and lower banks with a primary superheater between. Above the upper bank of tubes is a secondary superheater or reheater. The location of this reheater is such that the gases pass through it between the first and second passes of the boiler. An adjustable baffle or damper permits bypassing all or part of the gases around the reheater. The induced-draft fan and economizer are above the boiler and are

similar to the corresponding 350-lb. equipment except that the economizer is built for 1,400 pounds.

The stoker and combustion equipment are fundamentally the same as that of the 350-lb. boilers, and in fact all the steam-generating equipment takes approximately the same general space requirements.

The safety valves on the drum are set to blow at 1,200 lb. There are, however, small pilot valves on the outlet of the superheater set to blow at a slightly lower pressure. These give the boiler-room operators warning, permitting them to check the rise in pressure and thus save the large safety valves on the drum from blowing off. Valves underneath the small safety valves permit these to be taken off while the boiler is in operation and the seats reground.

The 1,200-lb. turbo-generator is built along standard lines, except that its parts have been strengthened to withstand the combined high pressure and temperature to which it is subjected. The unit operates at 3,600 r.p.m. and is of the horizontal four-bearing design. The turbine is of the straight impulse multi-stage type.

Boiler-feed water is supplied by a motor-driven centrifugal pump which raises the pressure of the main feed system from 425 lb. to 1,300 lb. for high-pressure service. This pump is driven by a slip-ring motor operating at 3,600 r.p.m. synchronous speed, which is automatically controlled so as to maintain the desired excess pressure on the high-pressure boiler. For preliminary operation and as stand-by equipment, a steam-driven centrifugal boiler-feed pump is mounted near the boiler so as to provide a source of boiler feed under the direct control of the fireman.

The power developed in the 1,200-lb. turbine is approximately 3,000 kw. The exhaust from this unit develops approximately 12,000 kw. in the 350-lb. main units. The high-pressure boiler should, therefore, be credited with a total output of approximately 15,000 kw.

Feed Water System

The plant has been arranged for operation in groups of four main units, each group being again subdivided into pairs with auxiliaries grouped for each pair. Each unit has a separate condensate return to the feed system from its hotwell to the surge tank. In this way there is no possibility of unbalancing the system by flow between units, as the water and steam leads have no interconnection. The water and steam flowing through the various heaters and deaërators are always in proportion, as the steam for heating condensate is extracted from the same turbine that supplies the condensate itself. Thus no valve adjustments are required.

The hotwell pumps are in duplicate on the condenser floor. Water from the hotwells is pumped to the generator air coolers and the turbine oil coolers. After flowing through this apparatus, the water passes through a small condenser installed for condensing gland leak-off steam from the high-pressure turbo-generator whenever that unit is running. The water flows next through the low-pressure extraction heater, that is, the 15th stage, then through the gland steam condenser and then to the deaërator. The deaërators are drained by the deaërator pumps, which are similar in design and action to the hotwell pumps on the condenser. The deaërator pumps discharge through the high-pressure (12th stage) extraction heater and from there to the surge tank. This tank is entirely closed to eliminate reabsorption of air and is intended to operate on hot water.

At normal operating loads the water will give off vapor and form its own steam blanket. At very light loads there would be a tendency to form a slight vacuum in the tank. In this case the steam blanket is formed by steam extracted from the gland leak-off. Relief valves have been provided and the tank covered to prevent heat loss. From the surge tank the water flows to the suction header of the boiler-feed pumps. From these pumps it is discharged through the high-heat-level condenser of the evaporators, to the economizers and into the boilers.

On the steam extraction lines to the heaters and deaërators a special type of flow valve has been installed. This valve acts as a stop valve and as a check valve to protect the turbine from steam or water which might flow back up from the heaters.

Drains from the heaters are arranged to pass as far as possible by gravity, being controlled by drip loops of

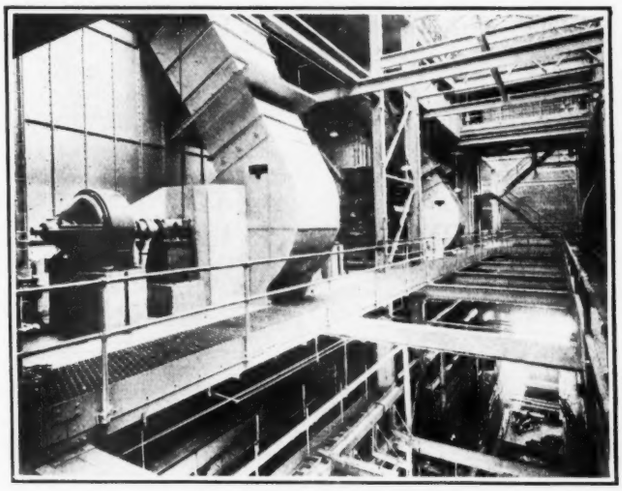

Fig. 6—View from economizer floor showing induced draft fans

the customary design. The drains from the gland steam condensers are dripped to the low-pressure extraction heater. A pump is provided to return this water from the low-pressure heater to the condensate line. If this pump should be out of operation for any reason, the water will back up in the low-pressure heater drip line until it has sufficient head to overcome a loop and enter the main condenser.

The evaporator plant is of the high-pressure, high-heat-level condenser type. This evaporator equipment has been used on the initial installation because of its simplicity of operation as compared to the low-pressure interstage turbine extraction system which is subject to variations in output corresponding to the fluctuations in the load on the turbine to which it is connected. The evaporator is of the three-effect type arranged for two evaporator shells per effect. Either raw fresh water or sea water can be used.

Water Supply

In the power station itself the water system for power generation is laid out for two sources of supply: a distilled water circuit forming the boiler feed lines with make-up and draw-off connections, and the power service system which supplies raw fresh water

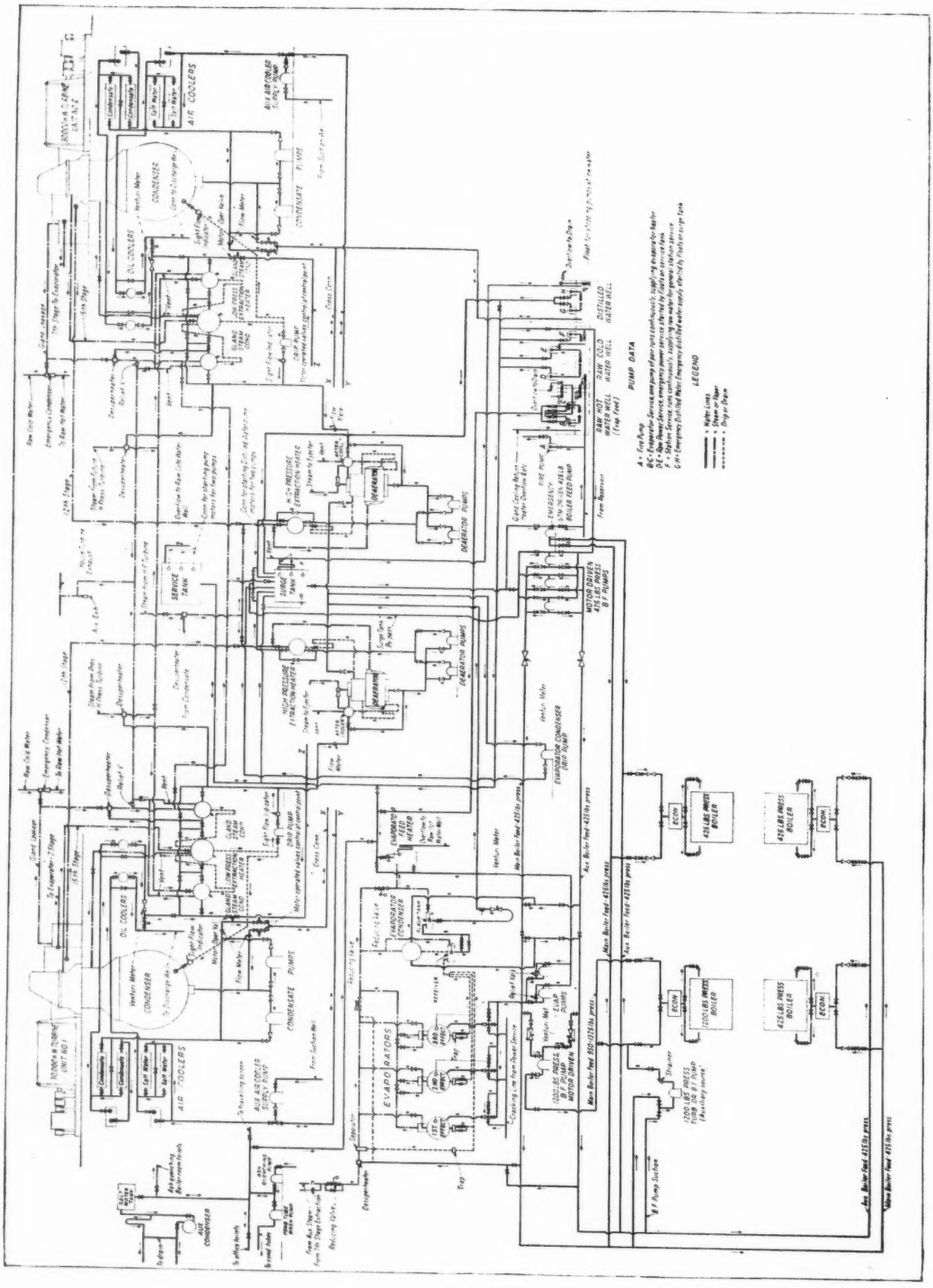

Fig. 7—Flow diagram for boiler feed system at Weymouth

for various power users and for boiler feed during emergencies.

The distilled-water system is balanced normally by the surge tank at the top of the system. Makeup from the evaporators is fed into the system at the deaërators. If the amount of makeup is greater than the feed requirements, the excess is drawn off and stored in the distilled water tank. This balancing of makeup requirements is normally accomplished by means of motor-operated valves connected to the suction and discharge of the condensate pumps and piped to the distilled-water well. The valves are manually operated from a control board which has on it indicating and recording instruments showing water levels in the tanks and also rate of water flow through condensate and makeup lines.

If for any reason the balance is not maintained by this method and makeup is still in excess of requirements, then the surge tank will overflow into the distilled water tank. Similarly, if the makeup is not sufficient, then pumps taking their suction from the distilled-water tank will automatically come into service by means of float controls on the surge tank and discharge into that tank. These pumps and the raw-water pumps can also be manually operated from the control board.

Auxiliaries and Through Power Supply

All the normally operating station auxiliaries are electrically driven, using alternating-current motors throughout. Motors of 25 hp. and less are, in general, supplied at 550 volts; those of greater capacity at 2,300 volts.

Power for all auxiliaries upon which the continuity of operation of the main units depends, is supplied from the auxiliary generators, driven by the main turbines through direct connection to the shafts of the main generators. These auxiliary generators have a rating of 2,500 kva. and generate at 2,300 volts, three phase. They are mechanically in phase with the main generators so that although they normally operate independently, they may be connected to the main bus through suitable transformers when desired. In starting up a main unit, all the auxiliaries are started from the main bus, but after the unit is in operation the important auxiliaries are transferred to the auxiliary bus of that unit, and thus supplied from the auxiliary generator independently of the main circuits.

Piping

Normal and high-pressure steam piping is welded throughout, flanged work having Sargol welded joints and the small piping having the threads sealed with a welded bead. The flanged joints in the 350-lb. boiler-feed discharge are of the Van Stone type with composition asbestos gaskets.

Important control and sectionalizing valves in main and auxiliary normal and high-pressure steam lines are motor operated, with their opening and closing stations located near the valves. Remote closing stations controlling all the valves are mounted on an emergency operating board in the outside firing aisle where the boiler-room partition isolates it from the steam piping. Additional remote closing stations controlling the valves located in the turbine room have been provided near the throttle valves of the first pair of main units.

For the data and material comprising this description *Power* is indebted to Stone & Webster, Inc., collaborators with the Edison Company engineers in the design and construction.

Sea Water Corrosion of Condenser Tube Material

A test of the resistance to sea-water corrosion of copper and its alloys, extending over a period of ten years, was described by W. H. Bassett and C. H. Davis at the February meeting of the American Institute of Mining and Metallurgical Engineers at New York, in a paper entitled "Corrosion of Copper Alloys in Sea Water."

Salt water from the East River, New York harbor, was barreled and transported to the laboratory for the test, a fresh supply being placed in service every six months. This water was pumped through the tubes, composed of the metals to be tested, and samples of these metals were also suspended in the water.

Since it was not convenient to remove the tubes for weighing, samples of metal from which the tubes were made were suspended in the water and weighed instead. After this test was made, an accelerated test by salt-water sprays was tried and proved much more effective.

Many of the alloys successfully withstood the ten-year attack of sea water. The best material to resist salt water should avoid the tendency both to pitting and dezincification. Copper-zinc alloys should be homogeneous brass containing between 70 and 85 per cent copper and composed largely of the alpha crystal. If tin can be added so as to become a part of the solid solution, no harm is done and benefit with some alloys is realized. Thus, with 60 per cent copper and 40 per cent zinc the addition of a small amount of tin increases the life from two to more than ten years.

Copper-tin mixtures of the alpha region and the cupro-nickels and copper-nickel-zinc alloys appear to be serviceable. The bronzes (Cu-Sn) do not become pitted but dissolve slightly, the losses in weight being somewhat greater than those of the better brasses. The sheet and tube samples of these alloys were in good condition at the end of the test.

Alloys unsuitable for condenser tubes are brasses containing more than 85 per cent or less than 70 per cent copper, as well as manganese bronze and aluminum bronzes. Brasses were best fitted to resist corrosion when annealed at 550 to 650 deg. C. (1,022 to 1,202 deg. F.). Such alloys containing tin were better at the 450 deg. C. (842 deg. F.) anneal.

Annealing of Muntz metal usually produces a surface layer of alpha crystals which have the practical value of resisting corrosion during the first month or two. After that time, however, the beta grains are reached and action progresses rapidly.

Both the salt-spray and the sea-water tests indicated that alloys are not endangered, but rather are protected by the presence of corrosion scales. Alloys that have the tendency to become pitted and dezincified are progressively and perhaps more violently attacked beneath this scale.

The spreading method of firing domestic boilers appears preferable to that of coking the coal in fire-pots of limited capacity. Tests indicated that with bituminous coal, admission of secondary air raised the efficiency at high ratings, but lowered it at the lower ratings. After firing and stirring the fuel bed, secondary air usually can be admitted to advantage.

Problems in the Utilization of Exhaust Steam

Amount of Heating Influences Type of Engine To Be Used—Condensing Operation During Summer Not Always Advisable—Bleeder Turbine Often the Most Suitable Prime Mover

BY CHARLES L. HUBBARD*

WHILE the importance of utilizing the exhaust steam in combined power and heating plants is appreciated by many, the best method of doing this is often a perplexing problem. As a matter of fact, neither the supply of exhaust nor the heating requirements are constant factors in the average case, and furthermore, the relation between the two not only varies from month to month, but often during different parts of the day.

To outline the method of procedure to be followed in choosing the proper machinery a factory plant will be taken where the load is practically constant throughout the year. To simplify the problem still further, the extra exhaust furnished by the late afternoon lighting load will be used in heating water for process work the next morning, the same being stored in insulated tanks. This reduces the variable factors to only one—the steam required for the general heating and ventilating of the buildings. The power requirements are approximately 300-kw., and 8,000 lb. of steam per hour will be needed for heating when the outside temperature is zero.

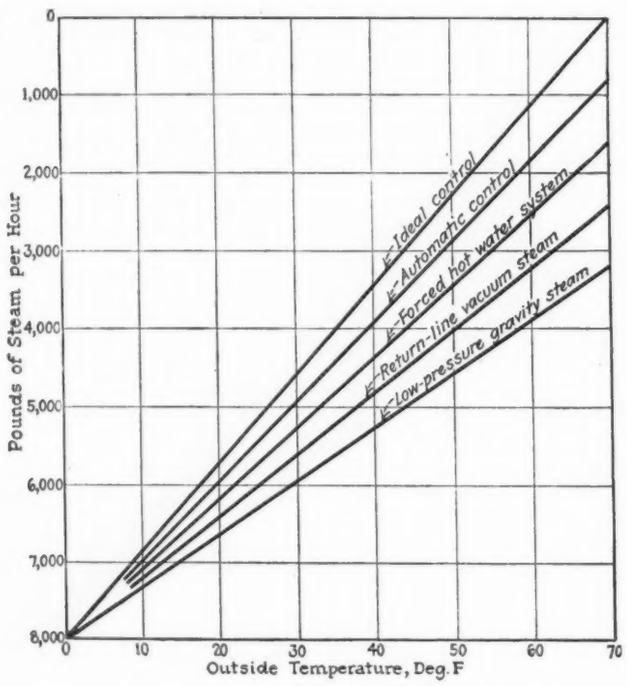

Fig. 1—Steam required by various heating systems

The problem is to determine what will be the most economical type of prime mover to employ and what arrangement of equipment will utilize the exhaust steam to the best advantage.

Six arrangements will be considered, as follows: (1) Non-condensing engine or turbine, utilizing the exhaust steam as needed and discharging the surplus outboard; (2) the same engine or turbine as in Case 1, with condensing equipment for use during the non-heating season; (3) a condensing turbine supplemented by a non-condensing machine to act as an automatic reducing valve for furnishing low-pressure steam for heating purposes; (4) an arrangement whereby the heating radiators are made to serve as a condenser for such portion of the exhaust as may be required for heating, while the surplus is automatically turned into a jet or surface condenser; (5) an arrangement similar to Case 5, but adapted to hot-water heating under forced circulation; (6) a bleeder, or extraction turbine with condenser.

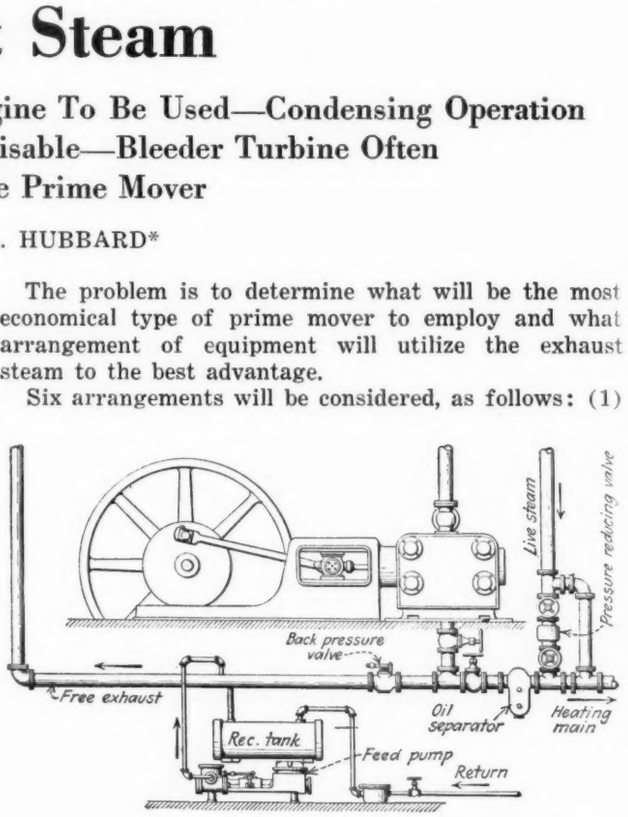

Fig. 2—Exhaust steam goes direct to heating mains

In determining the steam required for warming and ventilating the buildings, a heating season of 270 days will be assumed. Suppose, for the locality under consideration, the monthly average day temperatures are found to be as follows: September, 60 deg.; October, 50; November, 40; December, 30; January, 20; February, 30; March, 40; April, 50; May, 60 deg. The night temperature and such heating as may be required out of working hours do not enter into the present problem, as we are considering the utilization of exhaust only, and night heating would be done with live steam in any case.

The maximum weight of steam required for all heating purposes has been assumed as 8,000 lb. per hour. If perfect temperature regulation were possible, the

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quantity required at any outside temperature other than zero would be in direct proportion to the difference between the inside and outside temperatures. For example, in the present case, at 20 deg. above zero, it would be $\frac{70 - 20}{70} \times 8{,}000 = 5{,}700$ lb. per hour. From this relation a curve is easily constructed giving the steam requirements for any outside temperature, as shown by curve No. 1 in Fig. 1.

In actual practice the steam used will vary from this ideal by an amount depending upon the system of temperature regulation employed. For approximate work we may assume that with automatic control about 10 per cent of the radiation will be in use when the outside temperature reaches 70 deg., this being made up principally of the mains and risers. With hot-water heating, under forced circulation about 20 per cent will be in use under the same conditions; with return-line vacuum heating equipment with modulation valves, 30 per cent; and with low-pressure gravity heating and ordinary hand valves, about 40 per cent. In Fig. 1 various curves will be found giving the steam requirements per hour for these different systems.

Various Arrangements Compared

Let us now take up the different cases previously mentioned for utilizing the exhaust, and study each independently with the idea of determining the approximate quantity of steam required per year by the boilers under average operating conditions, with the assumptions previously made.

Case No. 1 is the oldest and most common arrangement, and simply consists in turning the exhaust from the engine or turbine into the heating system, usually under 1 or 2 lb. gage pressure, as shown in Fig. 2.

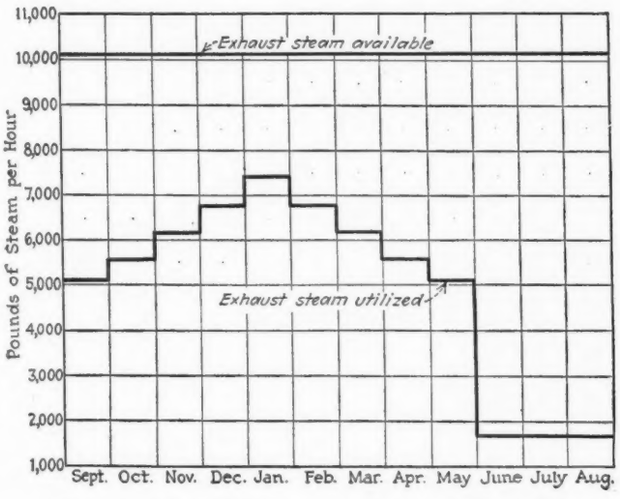


Fig. 3—Utilization of available exhaust steam

A back-pressure valve is provided in the free exhaust pipe for discharging the surplus out-board, while a live-steam connection through a reducing valve automatically makes up any deficiency. An ordinary single-valve high-speed engine is commonly used where a large proportion of the exhaust can be utilized for heating, and a four-valve machine, of more economical type, where more of the exhaust must be wasted. The engine must always operate under a back pressure, and varying quantities of exhaust steam are wasted, depending upon the season of the year and various local operating conditions.

As the plant under consideration is of some size, and the exhaust will be wasted during the non-heating season, we will select a four-valve, moderate-speed engine. The load is to be 300 kw., which, assuming a generator efficiency of 94 per cent and an engine efficiency of 92 per cent, will call for $\frac{300}{0.746 \times 0.94 \times 0.92} = 500$ indicated horsepower (very nearly). An engine of this type will have a water rate of about 24 lb. per

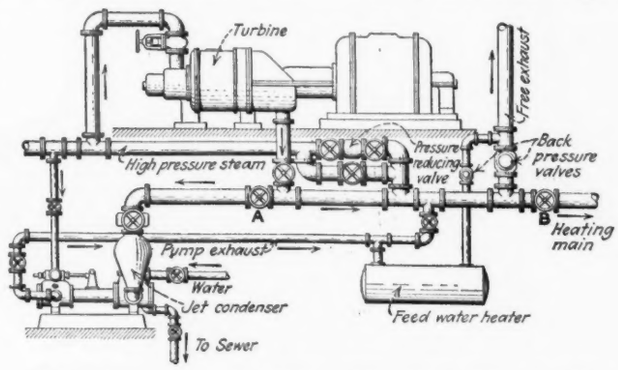


Fig. 4—Turbine exhausts into condenser or into heating system

i.hp. per hour at full load and will require $24 \times 500 = 12{,}000$ lb. of steam per hour.

While the weight of steam available in the exhaust for heating purposes can be quite accurately computed for a given set of conditions, it will average about 85 per cent for the type of engine under consideration, and we will assume this figure in the present case, which gives $12{,}000 \times 0.85 = 10{,}200$ lb. It is evident that there will always be more exhaust steam than can

STEAM REQUIREMENTS DURING THE YEAR

Month	Average Temp.	Pounds of Steam per Hour: Heating Buildings	Heating Feed Water	Total
September	60	3,900	1,160	5,060
October	50	4,550	1,060	5,610
November	40	5,200	970	6,170
December	30	5,950	860	6,810
January	20	6,650	760	7,410
February	30	5,950	860	6,810
March	40	5,200	970	6,170
April	50	4,550	1,060	5,610
May	60	3,900	1,160	5,060
June	70	....	1,700	1,700
July	70	....	1,700	1,700
August	70	....	1,700	1,700

be utilized for heating purposes, so that a uniform demand of 12,000 lb. per hour for all working days will give the maximum requirements.

The most steam that can be used for feed-water heating at any time is approximately one-seventh of that generated by the boilers, or 1,700 lb. per hour, leaving $10{,}200 - 1{,}700 = 8{,}500$ lb., which exceeds that required for heating the buildings in the coldest weather.

Taking a year of 50 working weeks of 45 hours each, or 2,250 working hours, $2{,}250 \times 12{,}000 = 27{,}000{,}000$ lb. of steam must be furnished by the boilers. Assuming an evaporation of 9.5 lb. of steam per pound of coal, this would require $27{,}000{,}000 \div (9.5 \times 2{,}000) = 1{,}421$ tons, for the working period.

Before making a further study of how this quantity may be reduced, let us prepare a chart showing the amount of steam wasted in the exhaust during each of the twelve months of the year. We will assume that a low-pressure gravity heating system is employed, with

hand regulation with the layout shown in Fig. 1. The steam quantities used per hour may be taken from curve No. 5, Fig. 1, for the different outside temperatures. These are found to be as given in column 3 of the accompanying table.

The quantity of steam required for feed-water heating varies inversely with the amount of hot condensation coming back from the heating system. For example, when 3,900 lb. of condensation is returned, 12,000 — 3,900 = 8,100 lb. of makeup water is required, which takes approximately 8,100 ÷ 7 = 1,160 lb. of steam for heating it. The other quantities in the table are computed in like manner and are sufficiently accurate for present purposes.

Referring to Fig. 3, the straight line at the top shows the pounds of exhaust steam produced per working

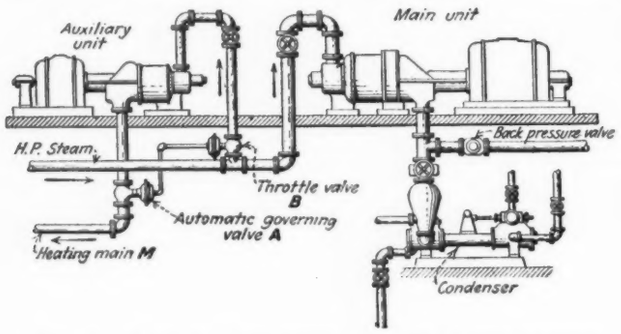


Fig. 5—Main turbine runs condensing and exhaust steam is supplied by auxiliary unit

hour during each month, and the curve below, the pounds of steam utilized during the same period. The distance between these lines, read to the same scale, gives the pounds of exhaust discharged outboard.

When To Operate Condensing

Let us now see what saving in steam may be made by adding a condenser for use during the non-heating season and also determine the time of year when the shifts from condensing to non-condensing should be made. This is case No. 2. We will assume a saving in steam of 20 per cent when operating condensing under the conditions of average practice. This gives a water rate of 24 × 0.8 = 19.2 lb. per i.hp. per hour, or a total of 19.2 × 500 = 9,600 lb.

As this study relates to steam consumption only, no account will be taken of the cost of condensing equipment or of cooling water, items that would necessarily be considered in the complete analysis of the problem.

The first step is to see if there will be any advantage in operating condensing during any part of the heating season, and warming the buildings by live steam. Taking the months of May and September when this condition would occur if at all, the total steam per hour when condensing would be 9,840 + 3,900 = 13,740, which exceeds that when running non-condensing.

If automatic control were used, the steam for heating during these months would average only 1,800 lb. per hour, as shown by curve No. 2 in Fig. 1, making the total 9,840 + 1,800 = 11,640 lb., as against 12,000 lb. when running non-condensing, in which case it would probably be best to make the shifts May 1 and Oct. 1.

Going back to the original assumption of hand control, let us determine the steam consumption for the year, assuming 2,250 ÷ 12 = 188 working hours per month. Operating non-condensing from Sept. 1 to June 1, 9 months, calls for 188 × 9 × 12,000 = 20,304,000 lb. of steam; and 3 months condensing calls for 188 × 3 × 9,840 = 5,549,760, making a total of 20,304,000 + 5,549,760 = 25,853,760 lb., or 27,000,000 — 25,856,760 = 1,143,240 lb. less than when operating non-condensing throughout the year. This would result in a saving of about 60 tons of coal, and the advisability of this plan would be decided by the cost of condensing equipment, cooling water, and price of coal.

Tests of a 300-kw. turbine operating at 175 lb. initial pressure and 28 sq.in. of vacuum, show a steam consumption of 6,300 lb. per hour, and 13,100 lb. when operating non-condensing. Increasing the former 2.5 per cent for operating the condenser pumps, calls for 6,460 lb. Substituting this for the engine would give a steam consumption of (188 × 9 × 13,100) + (188 × 3 × 6,460) = 25,808,640 lb. per year, which is practically the same as for the engine.

Influence of Climate

In a section of the country where the non-heating season was longer than used in the calculations, the turbine would probably prove the more economical, owing to its lower water rate when operating condensing.

A typical piping layout for this arrangement is shown in Fig. 4, in which case the plant can be run either condensing or non-condensing, by manipulating valves *A* and *B*. The exhaust from the auxiliary pumps is so piped that when the plant is operated condensing, it goes to a feed-water heater, and when non-condensing, to the heating main from which the feed-water heater takes its supply.

This, under certain conditions, makes a more economical arrangement than case No. 1, the advantage increasing with the length of the non-heating season.

In Fig. 5 is shown the arrangement used in Case 3, which is adapted to plants where varying quantities of steam at low pressure are required for heating or process work in rather moderate amounts. Power for the main plant is generated by a condensing turbine. Instead of obtaining the low-pressure steam by means of an ordinary reducing valve, which does no useful work, a non-condensing turbine is employed, arranged to start and stop automatically as the steam pressure in pipe *M* varies between slightly different limits.

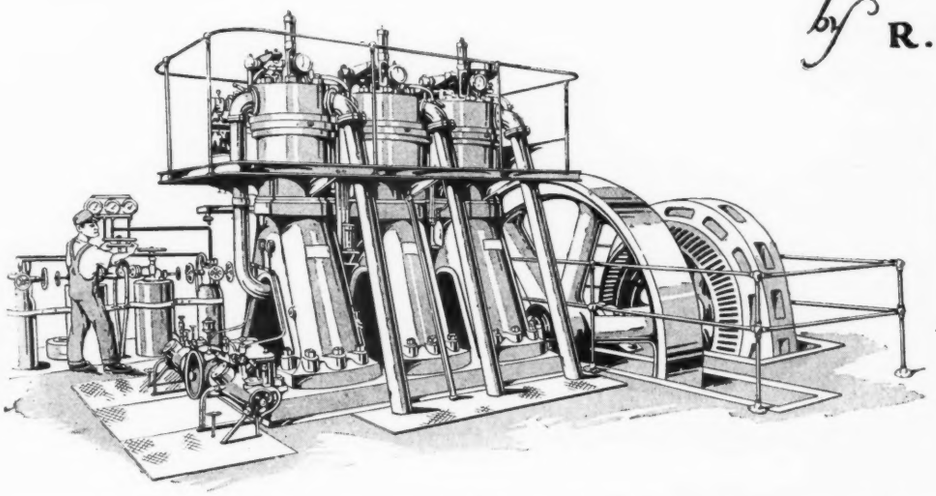
Valve *A* is similar in principle to certain types of pump governors and acts on the throttle valve *B* according to the steam demands connecting with pipe *M*. The power generated by this auxiliary turbine is transmitted to the switchboard and relieves the main generating unit of a like amount.

In a second article Cases 4, 5 and 6 will be covered, using the same assumptions employed in the cases already considered.

In electro-welding cracks in plates, forgings or castings, the crack should be chiseled out in order to get a good bevel entirely through the plate with a $\frac{1}{8}$ to $\frac{3}{16}$-in. opening on the back or to the bottom of the crack in castings or forgings. In making electro-welds in boiler plate of boilers, it is often the custom to drill $\frac{1}{2}$-in. holes well beyond the ends of the crack, chisel and bevel the crack and then weld. This lessens the tendency of further cracking in the given direction.

OPERATION OF DIESEL ENGINES

by R. Hildebrand *



The Causes of Crankshaft Troubles and How to Avoid Them

THE life of an oil-engine crankshaft is almost entirely dependent upon the care given it. If the bearings supporting the crankshaft were kept in alignment, there would probably never be a case of crankshaft failure. However, if it is not kept in alignment by periodic readjustment, it is only a question of time before even the heaviest shaft will break. A shaft is said to be out of line when its bearings are not supporting the shaft so that its center line is true and straight.

When an engine is erected, all the bearings are put in alignment. If the bearings would all wear equally, this alignment would be preserved indefinitely. Unfortunately, however, they generally wear and settle irregularly. The following are causes of misalignment of the shaft:

(a) A bearing may have run hot and the babbitt melted away or become displaced.

(b) One bearing may not have been lubricated as well as the others.

(c) The load may have been unevenly distributed so that one cylinder was heavily overloaded while another was underloaded.

(d) The initial pressure in the different cylinders may not have been equalized. Starting air of too high a pressure may have been used. The first fuel injections during starting may have been excessive, causing an abnormally high initial pressure.

(e) The composition of the babbitt may not have been alike in all bearings.

(f) The foundation may have settled unevenly, the result of the engine's standing partly on an old and partly on a new foundation, or if the foundation rests partly on filled ground and partly on firm soil, or if the top of the foundation has deteriorated by oil leaking below the bedplate.

If any of the conditions mentioned are allowed to exist, they will result in misalignment of the main bearings and eventually in crankshaft failure.

It may sound strange, but it is nevertheless a fact that the short starting period causes as great wear on the bearings as the actual running of the engine, and even greater. This is because an oil film is maintained between shaft and bearing during the running of the engine. At the moment of starting this oil film does not exist and the shaft rests and rubs metal on metal instead of floating on an oil film. Keep in mind that conditions are entirely different in a Diesel engine compared with a steam engine. A steam engine in general is started with the throttle barely open, making the pressure on the piston and in the bearings at the beginning, very low as compared with normal operation. In a Diesel engine the full piston pressure is reached right at the start, because of the compression, while it takes several revolutions to establish a complete oil film all around the journal.

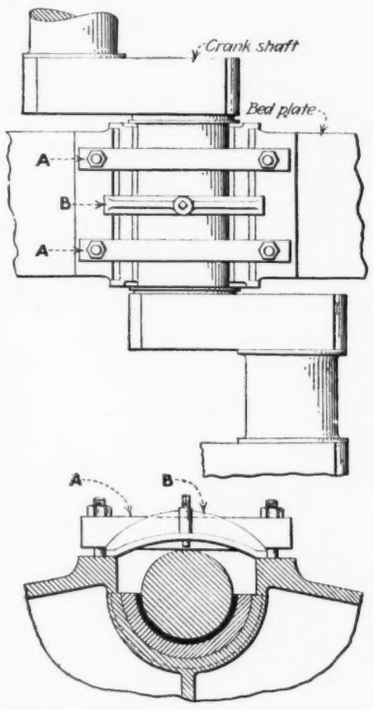


Fig. 1—Testing bearing wear

Under the circumstances, the starting-air pressure should not be higher than necessary, if possible not higher than the compression pressure. The pressure needed to start the engine will depend on the conditions of the unit and on the number of starting valves. An engine with leaky piston rings, exhaust and inlet valves, etc., and equipped with only one starting valve, will naturally require a higher starting-air pressure than an engine properly maintained and using the starting air on two or more cylinders.

Excessive pressures should be avoided at the first ignition. Before starting, the fuel pump and fuel

*Chief engineer, Diesel Division, Fulton Iron Works Co.

pipes should be primed in such a manner that excessive pressures do not occur. The writer suggests that the engineer follow strictly the advice of the manufacturer as to how the fuel system of his engine should be primed. What is proper for one type of engine may be wrong for another. The heavy firing that can be heard and felt in some engines when the first ignitions take place are not only objectionable for reasons already stated, but they also overstrain and thus endanger the crankshaft.

When one or more of the bearings carrying the crankshaft drop out of line, from any one of the causes already mentioned, the shaft deflects excessively each revolution. The constant overstraining of the shaft causes fatigue and crystallization of the metal.

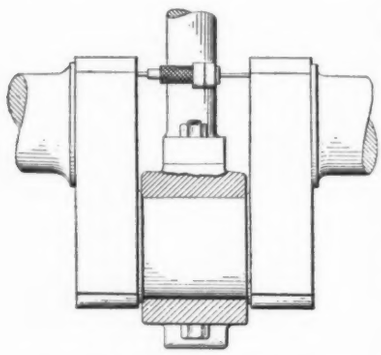


Fig. 2—Micrometer measures crankthrow distances

True enough, a crankshaft will not break right away if the engine is abused, but the shaft may develop a fine surface crack, particularly when the faulty starting and operation are repeated and continued. This crack gradually deepens, and finally the crankshaft ruptures without an apparent cause. If the fracture is then inspected, it can be seen that an old crack existed, having its surface worn by the constant working or rubbing, the old crack looking as if it were a flaw in the material. Consequently, faulty material is generally blamed instead of the manner of operation.

Testing Crankshaft

A crankshaft may be tested as follows: A good, sensitive machinist's steel spirit level (ordinary levels not being sensitive enough) placed on the journals of the shaft generally shows whether the shaft is in alignment or not. It is better, however, to use the shaft testing tool furnished by the engine manufacturer. Fig. 1 shows the tool furnished by one builder. When testing the shaft, replace bearing cap by straps *A*, as shown, lay a piece of wood or copper between strap and shaft and tighten the nuts, thus pressing the shaft tight on the lower bearing shell. Bring testing tool *B* in place and measure with feeler gage the distance between shaft and setscrew of the testing tool. The measurements thus obtained should be compared with the original ones stamped on the bedplate at each bearing by the erector or inspector of the engine. Such a testing tool enables the engineer, after the shaft is once properly aligned, to check conveniently and exactly the alignment.

Another method of testing a crankshaft, which may be used as a check, is to measure the distance between the crank arms by means of a micrometer, when the crank is in its lower and upper dead-center positions respectively, as shown in Fig. 2. This measurement should be made with pistons and connecting rods in place and with the main bearing caps bolted down. Care should be taken that the measurement is always taken on exactly the same spot which should be marked in some manner on the crank arm, for instance by a small spot face. The measurements taken when the crank is down and when up will be alike within one or two thousandths of an inch if the crank is in alignment. However, if the measurements are not alike, they will indicate a misalignment. For instance, if the measurements in Fig. 3 show the crank arms open and closed when the cranks are up and down respectively, it indicates that the central bearing is low.

This method is also useful in checking up on the alignment of the first outboard bearing, in which case the measurements should be made on the first crank nearest the flywheel when the flywheel is in place on the shaft.

There are not always external indications which can be relied upon to show when the shaft bearings need to be realigned. Uneven heating of the bearings and knocks in the engine that cannot be overcome by reducing the clearance in the bearing and pin boxes, sometimes indicate misalignment. The only safe course to follow is to inspect and if necessary realign the shaft at least every 12 months, or better, every 6 months if operation is continuous. This interval will depend on the individual operating condition of the engine. For instance, if an engine is operated in a dusty atmosphere so that fine dust continually enters the lubricating oil, the bearing wear may be rapid. The shaft should then be given more frequent attention.

Records Should be Kept of Wear of Each Bearing

It is advised to keep a record of the wear of each individual bearing, as these data will aid the operator in the future. The wear may be charted in a diagram and the different rates of wear between different bearings and between different engines compared.

It has been stated that one of the causes for a crankshaft getting out of alignment is a bearing that has run hot. The question arises as to what may cause

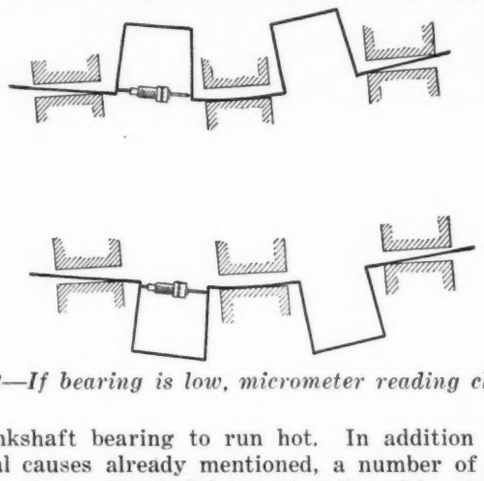


Fig. 3—If bearing is low, micrometer reading changes

a crankshaft bearing to run hot. In addition to the several causes already mentioned, a number of others can be cited: The bedplate and outboard bearing may be out of alignment or impurities such as grit and emery may have passed into the bearing, the lubricating oil may be unsuited, or though originally of good quality, it may have become gummy or otherwise deteriorated.

In the case of a bearing running hot, its oil grooves and oil holes frequently fill up with melted babbitt. It is, therefore, advisable to take out the shells of the bearing that has run hot and inspect the oil grooves and oil holes, or this bearing may run hot again owing to insufficient lubrication.

If a force-feed oiling system is used, the pipe connection supplying oil to the bearing may leak or the shims of some bearings may not be pushed tight against the shaft, thus allowing too much lubricating oil to escape, cutting other bearings short of oil. The same will be the case if some bearings are worn excessively, allowing too much oil to escape. An oil drilling of the force-feed lubricating system may be clogged up and the corresponding bearing is not getting a sufficient amount of lubricating oil.

Testing the Bearing Clearance

The clearance of the bearing should not be too small. Allow from 0.004 to 0.006 in. clearance for shafts up to 8 in. in diameter and 0.006 to 0.008 in. for larger shafts. This clearance may be tested as follows: Remove the cap and the upper shell and place a fine thread of lead on top of the shaft. Then bring the upper shell and cap in place and tighten their nuts, the shims being in place. Now remove the "lead" and measure its thickness with a micrometer. If the clearance is insufficient, add a shim on each side of the bearing and draw the nuts of the bearing cap tight, so that the upper and lower shell rest metal on metal, the shims being between the shells.

Whenever a bearing shows signs of not being lubricated properly, increase the amount of oil fed to the bearing. After shutting down the engine, find and eliminate the cause of the disturbance. As a general rule, be liberal with the oil supply to the crankshaft bearings and also to the crankpins and wristpins, but try to reduce the oil splashing in the crankcase as much as possible.

It appears desirable to circulate no more oil to the bearings than necessary. In a sight-feed gravity system, the quantity of oil fed to each bearing and pin can be conveniently adjusted. In a forced-feed system, where a certain pressure must be maintained to force the oil to the wristpins, through the hollow connecting rods, the excessive oil splashing can be reduced only by keeping all bearings well adjusted and all shims between the bearing shells tight against the crankshaft.

As the lubricant in a bearing reduces friction and consequently also the heat caused by friction, it is obvious that the temperature of a bearing is a good indication whether or not the lubrication is effective. The temperature of the bearing is naturally higher than the temperature of the surrounding air, which, in our case, is the temperature in the crankcase. As one cannot accurately judge the temperatures of the bearings and crankcase with the hand, the engineer should take these temperatures and record them in the engine-room log.

It should be noted in connection with the introduction of secondary air in domestic heating boilers, even in the case of anthracite or coke at high ratings or high volatile bituminous coal where it is actually needed, that this possibly may enter through the open slots of the firedoor at such a low velocity that it would never have a chance to combine with the greater portion of the carbon monoxide at the rear of the fuel bed. It is more to the purpose to mix oxygen filtering around the sides of the fuel bed with the unburned combustible, especially at medium or low ratings.

Renewing Foundation Under Steam Plant, with Station in Service

Steam station "L" of the Portland Electric Power Co. was started in 1910 and now has an installed capacity of 23,500 kw., consisting of three turbines having ratings of 12,500, 6,000 and 3,000 kw. respectively, and a 2,000-kw. reciprocating engine. There are twelve boilers, eight of which are in the original building and four are a seperate installation. The station, which is 165 ft. long by 135 ft. wide is built on a reinforced mat 3 ft. thick supported on piles spaced 3 ft. centers both ways over the entire area. About 6 in. of the pile head was embedded in the mat.

During extreme low water about 14 ft. of the piles is above the level of the water in the river. Several buildings in the city of Portland have the foundation piles cut off 14 ft. or higher above low-water level, but the

Concrete columns in center, wood piles on the left. One concrete column replaces 14 ft. of the top of four wood piles

moisture in the ground prevents decay. Under station L the piles were moist at all times up to the concrete mat, but decay occurred at the extreme top of the piles, due to a combination of moisture and heat and also because the ground settled away from the mat about two inches.

By the latter part of 1923 this decay had reached a condition where there was a possibility of serious settlement occurring to the plant and equipment. Under the ashpits the top of the piles were badly charred, leaving the concrete mat practically unsupported. After a study of several methods for remedying the difficulty, it was decided to cut 14 ft. off the top of the piles and build up this distance with a precast concrete structure, this work, which required the cutting off of about 2,500 piles and replacing them with 625 concrete structures, was done with the plant in regular operation. A general idea of how this work was carried out is shown in the figure. Each of the concrete columns replaced 14 ft. at the top of four wood piles.

Accomplishments in the Study of Cooling Electric Machines

By C. J. FECHHEIMER
Power Engineering Department, Westinghouse Electric and Manufacturing Company

IT IS easy to understand why a steam engine will not deliver more than a given amount of power at a definite speed; the steam pressure and cylinder dimensions determine its maximum delivery. In the electrical machine it is different; it is heating that is the principal limitation in the majority of generators, motors and transformers.

In many machines the insulation consists of fibrous materials, such as paper, cotton, linen, etc. If the temperature exceeds certain values for a sufficient time, the insulation becomes brittle, chars and fails; a short-circuit then takes place and the machine burns out. In many of the large machines non-combustible

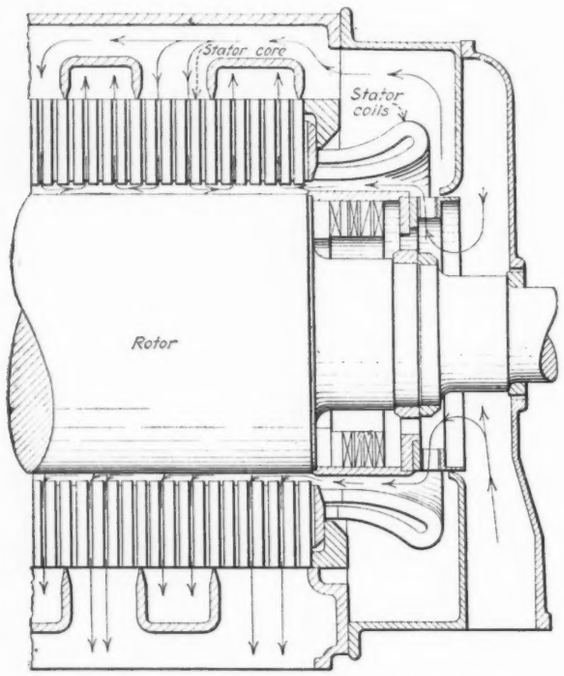


Fig. 1—Scheme of ventilation system used in turbo-alternators, as studied in the turbo model
Arrows indicate direction of air flow.

material, such as mica, is relied upon for insulation. With such materials the temperature may be higher than for fibrous insulation without endangering the life of the machine. Experience has indicated that with this type of insulation it is best not to run at too high temperatures, and the desire to secure safe operation has prompted engineers to fix upon certain values as the maximum for mica. It is therefore of great importance that the designers proportion the parts of the machine in such a manner that safe values of temperature will not be exceeded. On the other hand, if the temperature rise is low, the machine may be larger than necessary and will not be marketable. Also, in the past, considerable changes in temperature rise have been effected by changes in the ventilating system.

Those problems associated with temperature in electrical machinery are of great importance, perhaps more than any others that confront the designer of apparatus. But they embody so many intricate relations that for many years the designer estimated the increase in temperature above the surroundings only by comparison with other apparatus. When he was called upon to design a machine that was to deliver considerably more power or was to operate at much of a departure in speed from the other apparatus previously built, he was unable to predict within a wide margin how far he might go. Only in the last few years have we begun to place this complex problem on a scientific basis. Many parts of the problem are still unsolved, but it is felt that sufficient progress has been made to warrant the giving of information regarding the manner in which the researches have been, and are being, made.

Method of Obtaining Data on Heat Flow

It was recognized at the outset that it was hopeless to secure positive results by attempting to analyze the results of tests on complete machines. The method adopted by the engineers engaged on the problems at the Westinghouse Company, was to break the composite into its constituent parts and then to make a study of the heating problems of those parts. Such studies were to be made largely by experiment on models, but mathematical analyses were to be made whenever possible. Even such studies are usually difficult and a few of them have been fruitless. But enough of them have proved to be successful to justify the engineers who are conducting the researches to believe that they are on the right road. When solutions of the heating problems in models are obtained, the results, or suitable combinations of the results, are applied to machines as built.

To be more specific, the case of the large steam-turbine driven alternator will be considered. The number of cubic feet of air per minute needed to absorb the heat generated by the losses is readily calculated if the temperature increase of the air is assumed. But the distribution of the air between many parallel paths and the pressure required to drive the air through the ventilating passages were unknown, and the researches consisted in finding methods for determining them.

Accordingly, two models were built in which the stationary parts were made of hardwood with ventilating ducts as in a machine, and arrangements were made for measuring the total volume of air, the volume discharged through each vent duct and the total pressure. The models were provided with a rotor that could be operated at speeds up to the peripheral speeds that obtain in large turbo-alternators. Each of the many factors that might influence the flow of air was investigated independently, which enabled the engineers

to derive mathematical equations. With the use of these the pressure needed to drive a given volume of air and the distribution of the air can be predicted within a comparatively small percentage of error.

Most steam-turbine driven alternators are provided with fans on the shaft of the rotating part, which deliver to the generator the cooling air. Data on fans as used in electrical machinery were not available, consequently, a long series of tests was conducted on fans of various designs, imitating as nearly as possible the conditions that obtain in electrical machines. From those tests the characteristic curves co-ordinating volume with pressure, power input and efficiency were obtained. From well-recognized proportionalities, involving the dimensions and speed, the characteristics of similar fans, but of different size and for other speeds, are readily calculated.

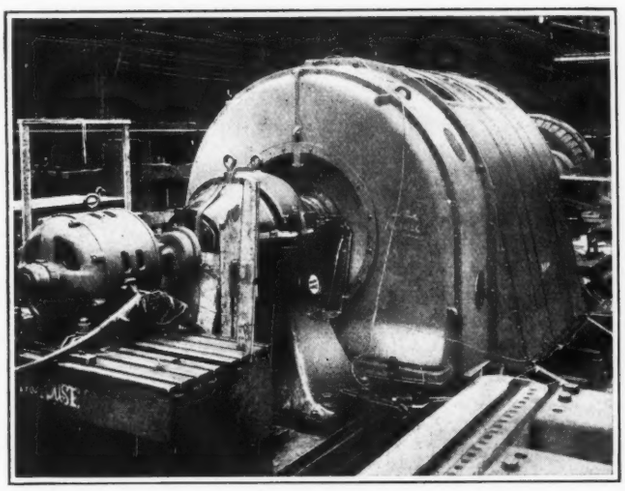


Fig. 2—Turbo-alternator in which the system of ventilation, as studied in the model, was used

Air Flow Not the Whole Problem

But the air-flow problem is not the whole problem involved. The determination of the rate at which heat is picked up by the moving air streams from the surfaces of the vent ducts depends upon the temperature differences between the surface and the air, upon the velocity of the air stream, and upon the character of the disturbances (eddies) in the air stream. The latter is one of the things that make this research a difficult one, and it is necessary to imitate in small models the restrictions in the vent duct as they are in electrical machines, and thereby secure an approximation to the air-eddying condition. In this investigation the surfaces were heated electrically and the temperatures measured by thermocouples.

There are differences in temperature between the ventilating duct surfaces and those parts in the stack of iron stampings which are not exposed to the air streams. The heat generated in these stacks must be conducted to the cooling surfaces from lamination to lamination. Tests were made to determine the conductivity of such a stack and then, by applying a little mathematics, the temperature differences were readily calculated.

The heat generated by the losses in the copper is a combination of the loss due to the electric current flowing against the resistance, and very complex electric eddy-currents in the copper. The losses due to such eddies fortunately have admitted of mathematical analyses, the accuracies of which have been checked experimentally. All the generated heat in the copper must be conducted through the insulating wall, and a large number of tests were made to determine the values of the thermal conductivities of various kinds of insulating materials. From a knowledge of those values, and the losses in the copper, the difference in temperature between the copper and the outside of the insulating wrapper may readily be calculated. Heat is also conducted along the copper longitudinally, and a mathematical solution of this part of the problem and its bearing upon the temperature has been obtained.

Usually, the copper temperature is most vital and most difficult to predict. It is determined by a series of calculations, some pertaining to the losses, some to ventilation, some to heat dissipation from the cooling surfaces, and some to heat conduction. Each has been secured by one or several researches. The studies have raised this very important and difficult problem from the empirical to the scientific state. This has been one of the principal means for giving to the consumer more for his money than he has ever secured before.

A Change in Hydraulic-Turbine Guarantees Needed

By John S. Carpenter

An engineering guarantee, as generally construed, means that the builder will back his product under the conditions specified to the extent of replacing defective units or parts thereof. In some cases a penalty clause is part of the guarantee, although usually the customer considers that the manufacturer's reputation is at stake and that he will in case of non-fulfillment make good to save his sales policies and reputation.

The value of a guarantee is quite a variable quantity and depends largely upon how it is drawn, what is really covers as against what it may seem to cover, and the reputation and assets of the firm or corporation name affixed. The clearest and most definite guarantees are those written with short sentences and free from involved technicalities of doubtful and ambiguous interpretation. One should very carefully note where the guarantee begins, exactly what quantities are covered and where the guarantee stops. Some engineering specifications are so loosely worded that in the event of trouble the court might have to decide just what was guaranteed and how far. The name signed to an engineering specification containing a guarantee is of much importance, as is also the builder's financial rating. It is not to be expected that any large and well-known corporation would try doubtful methods, for even good will is worth something and publicity is a powerful weapon.

It is generally held that in the case of non-fulfillment of a guarantee, a penalty cannot be exacted unless there is a bonus clause accompanying the penalty, or unless the bidder expressly agrees to a penalty without a bonus. The best practice appears to be to set a limit for shortage in guaranteed results or efficiency and to reject any and all apparatus falling below such limit, without penalty.

In the case of hydraulic turbines, efficiency and

power curves are always part of the guarantee. On account of the extremely diversified conditions under which hydraulic turbines are installed and operated, it frequently happens that the curve may shift slightly up or down the power scale without materially changing the shape of the curve. Again, curves obtained by test in place have changed very greatly from the guarantee curve and not because of any manipulation of test results. At first thought this might seem a reflection upon the turbine builder, but this is not the case. The draft tube and scroll case conditions are frequently so restricted in height or width, or often both, that it is difficult to anticipate what the operating results will be unless a model setting is first tested with the model runner.

Rebuilding Old Plants

More and more of the older hydro plants are being rebuilt, and in every case more power is expected out of the same hydraulic cross-sections, and with better efficiency. The higher-speed turbines are very sensitive to the form of water passages to and from the turbine. Rebuilding old plants now obsolete is going to form an increasingly larger proportion of the hydraulic turbine business as time goes on. In almost every case noted, the owners of the obsolete plant are extremely reluctant to make any changes in the settings, and it is with the greatest difficulty that they are finally induced to do any excavation or other work helpful to the crowded draft-tube conditions.

In the face of such conditions and what is expected of the turbine builder, how is an efficiency curve to be construed? Is it to be a one-point guarantee for efficiency and power, or is the whole curve to be taken point for point from half to full load? Pump builders are agreed to take one point on the curve and clearly define that point. The rest of the curve is expected to come substantially close to the guarantee, but the builder is not held down to it. To the writer's knowledge no such practice exists among hydraulic-turbine builders, many of whom guarantee half, three-quarters, best efficiency and full load, while others guarantee fifty, sixty, seventy, eighty, ninety, ninety-five and full-load percentages. Thus the turbine builder ties himself down within entirely too close margins. The writer proposes, for a new turbine plant, that a turbine shall be considered up to guarantee if the best efficiency by recognized test shall be shown to be not more than one per cent below the guaranteed best efficiency and that the full-load horsepower shall not be less than the contract horsepower nor over 7 per cent more than such guaranteed full load. This last provision would be desirable in cases where the water supply is maintained within close limits or where water is scarce.

Adjusting Disputes About Guarantees

In disputed cases where the test curve is materially different from the guarantee curve, or part may lie above and part below, let the final decision be made by a jury of hydraulic engineers, one for the customer, one for the builder, the two to choose a third and the three supervised by a judge of an equity court.

By the common method of financing purchases of water-turbine equipment there is usually a substantial final payment due about the time the turbine equipment gets into operation. Lower head than normal and scarcity of water are frequently made pretexts on which to hold up final payment pending a test, and this is often dragged out over a half year. It is suggested that it be made part of the contract that in cases of conditions unsuitable for an acceptance test, the final payment is to be made within sixty days after the hydraulic equipment is ready to run. The customer is protected in any event by his guarantee.

There are a great many plants, very antiquated, that cannot be classed with the merely obsolete plants already referred to. These plants now to be mentioned are so far out of date that in almost every case their builders have gone out of business or are now so far behind the times that their bids would not be considered for rebuilding. Consequently, modern turbine builders frequently receive proposals to furnish new runners to go into the old cases, and usually no new gates are wanted. It is a matter worthy of remark how calmly bidders are asked for actual guarantees on such a misfit combination. In almost every case the results are unsatisfactory and the case often goes to the courts.

Difficulties in the Courts

Every engineer knows how unsatisfactory it is to get even a reasonably clear engineering case through a court, but a case of this kind transcends reasonable knowledge. In this connection it will be of interest to the hydraulic-turbine fraternity to know of a related case in the centrifugal-pump line. A 22-in. double-suction pump required a new impeller for slightly greater capacity and better efficiency, as the pump builder fell down badly on the guarantee. Requests for bids accompanied by detail drawings were sent out to reputable builders, and within a week replies were received from all politely but flatly declining to bid. Similar action in cases of hydraulic turbine rebuilding, where the bidder is refused the opportunity to furnish with the runner a proper gate casing and draft-tube connections is worthy of serious consideration by hydraulic-turbine manufacturers. There is quite a little of this business available, but it usually proves to be a thorn in the side. The builder has no chance of doing a creditable job unless he can furnish with his runner a suitable gate casing and draft-tube connection, as the modern turbines are quite sensitive so far as efficiency and power are concerned when in combination with parts they were never meant to function with.

The foregoing are outstanding points that should be incorporated into standard specification in a just and fair manner, so that both customer and builder may be protected from unjust expectations and subsequent recriminations.

Tests on domestic heating boilers indicate that products of combustion with ordinary fuel usually leave the fire-pot as low as 200 to 300 deg. F. at low rates of combustion and from 500 to 600 deg. at the highest rate of combustion. All these temperatures are far below the ignition temperatures of carbon monoxide, which is about 1,220 deg. F.; of methane, about 1,200 to 1,380 deg. or of hydrogen, about 1,080. Judging from low stack temperatures, it is probable that little combustion continues after the gases have passed through the first and possibly the second sections. The major portion of the heat release must be effected within the fire-pot itself, or it will never be transmitted to the heating system.

Custom-Made Power Plants

HARDLY a month passes without the announcement of the completion of a power plant embodying features heretofore unused. In fact, things have reached the point where it is seldom that an established design is accepted in whole for use in a new plant. That the gains traceable to the alterations in details are almost insignificant is a claim of many engineers, and that the lack of standardization increases the cost is admitted by those familiar with the subject.

In many instances such lack of standardization is due to the designing engineer, who has a tendency to impress his own personality upon the plant's layout. Frequently, consolidation of existing systems brings on the undesirable conditions. On the other hand, there are holding companies that have adopted a general scheme of standardization and now have uniform generator voltages, standard transformer, one boiler pressure and the same turbine capacities in the new plants. If such a plan were more generally adopted, installation costs would undoubtedly be much under present ones.

Pay-as-you-go Engineering

THE ideal method of bringing a plant up to scratch is to have a competent consulting or operating engineer study the whole layout carefully, consider all possible improvements, weighing the cost against the obtainable savings, and then submit a comprehensive reconstruction program to be carried out as rapidly as possible without interference with production. Unfortunately, it is impossible, nine times out of ten, to secure approval of such a program. In many cases the considerable capital required is not available. Even where it is, the financial management is generally inclined to avoid heavy plunges into improvement expenses on the "say so" of the engineer, fearing that he may be over-optimistic regarding the results to be obtained.

In such cases the engineer must proceed, if at all, on a pay-as-you-go basis. He looks over his ideal program for those items where a moderate expenditure will make the biggest showing in savings. Perhaps the boilers are overhauled, leaks stopped in the settings, baffles repaired and a few of the most necessary instruments installed.

After six months or a year of improved operation the engineer can go to the management with figures as to the saving effected and ask that the amount of the saving be turned over to him for further improvements. Such a reasonable request is likely to be granted. In this way a plant can often be completely revamped in five or six years without using any new capital whatever and with a continually growing appreciation of the engineer's services.

Utilizing Circulating-Water Heat

PROCESS heat is not invariably required at temperatures above 212 degrees. Where considerably lower temperatures will suffice and where more power is needed, consideration should be given to the possibility of carrying some vacuum on the engines.

The carrying of vacuum on exhaust-steam lines involves the problem of air leakage and for that reason will in many cases be considered impracticable, even where the process could utilize steam at such a pressure. But the process heat can frequently be used in the form of hot water, particularly in certain textile finishing operations. In such cases the necessary amount of good-quality water may be circulated through one or more condensers and discharged to the process. It will almost always be necessary to raise the exit temperature considerably above that normally used where low steam consumption per horsepower is the only object, and this will, of course, involve a considerable loss of vacuum. At the same time "half a loaf is better than none," and a vacuum of ten or fifteen inches means a substantial increase in the power obtainable from a given flow of steam.

This method of operation is not new. It has been applied in dye works and other process plants and has also been used for the heating of buildings by hot water. At the same time there are probably many manufacturing plants where the savings obtainable in this way have not had proper consideration.

More Co-operation Needed

IF IT were true that all power produced from waterfalls was cheap power and that all such developments contained a pot of gold at the end of a rainbow, there might be some rational reason for the agitation that has been raised about the state rights in water-power developments. But the fact remains that many water powers are uneconomical to develop and cannot be made to produce power at a cost to compete with steam plants.

Political interests seldom if ever raise objections to what shall be done with power produced from fuel. It can be generated where it best pleases those who are building the plant and transmitted to where there is a market without any restrictions, other than the rate at which the power may be sold, which is determined by the utilities commission. But when it comes to a water-power development, everybody gets excited. It makes little difference whether it is a source of cheap power or one that may have a difficult time to compete with power from fuel, or can be developed only because the capacity of an adjacent steam power system has grown to where it can economically absorb the water power—the objections are in general the same.

The State of Maryland's action toward the Conowingo development is a good example of the attitude in other

states. This power site has attracted attention for many years, but no way could be found to make its development economically possible until now, when there has grown up in a neighboring state a steam-power system that can absorb the large amount of secondary power that will be available due to the nature of this development.

This attitude is in striking contrast to that of Governor Pinchot of Pennsylvania, who has taken the broader view of the problem and believes in the generation of power where it can be done most economically and its transmission to points where it can be used most advantageously, through interconnected systems that know no state boundaries. Recently Governor Smith of New York, who heretofore, has been opposed to power being transmitted out of the state, signed the New York, New Jersey and Pennsylvania tri-state treaty for joint use of the waters of the Delaware. This act would indicate that the Governor is abandoning his policy of isolation and coming over to one of co-operation with the neighboring states.

The State of Maine for many years has opposed allowing water power within her borders to be developed for transmission out of the state. Today seventy-five per cent of the undeveloped water power in New England is in the State of Maine, but it is not attracting industries from other New England States. If the policy of isolation has had any effect, it has caused a shifting of industries from neighboring states to the South; this is particularly true with respect to the textile industry. Transportation, labor, raw materials and markets are of infinitely more importance than power in the location of most industries. Unless these essentials are available, restrictions on transmission of power will not bring industries into any locality other than those that would naturally locate there.

Should Exhausted Heat Be Commercialized?

THE answer is obviously in the affirmative. Heat now exhausted should be utilized, but present conditions often render it difficult or impracticable. Where waste is greatest and energy representing trainloads of fuel is poured steadily day after day into the condenser cooling water, circumstances often conspire to make its commercialization a difficult problem.

Although fuel is limited, the point of exhaustion is not imminent. The cost of obtaining it, however, is a serious factor, since the easily accessible supplies are rapidly diminishing. A greater premium will be placed eventually upon better methods of utilizing the raw material.

Improvement in the power station may take the form of a more efficient energy cycle, exhausting less heat to the cooling water or utilizing to better advantage the energy thus discharged. The former involves higher temperatures, large capacities and a host of technical complications, besides limiting the product to one commodity—electrical energy. On the other hand, the combination of an energy-producing cycle with the supplying of low-head heat, disregarding the question of byproducts, represents a heat-energy distribution problem rather than one of engineering research and pioneering.

Actual conditions, however, indicate that too much should not be taken for granted. The industry of supplying steam for heating and other purposes has recently made definite progress, and further improvements are not unlikely. More important, however, is its higher thermal efficiency. Two or three times as much energy in the fuel is thus usefully converted as that by the pure energy cycle. From this viewpoint the plant supplying low-head heat is primarily better adapted to cope with rising fuel costs.

On account of the great fluctuations inherent in a heating-demand curve, the matter of customers and their individual needs is highly important. Industries whose loads tend to balance other irregularities deserve encouragement or promotion. Building up a favorable load demand may extend over a considerable period and represent a major problem.

Assuming that it should become necessary to commercialize wasted heat, stations that delay too long in coping with the situation may find it difficult to secure desirable consumers in a reasonable length of time. Since promotion and sale would become relatively so important to success, it would seem that well-laid plans supplemented by definite promotional effort would mean a worth-while advantage. From the fact that combined cycles have met success in many instances, it is probable that adequate reward awaits their exploitation on a larger scale.

Boiler Accidents in the United Kingdom

THE annual report of the Manchester Steam Users Association summarizes thirty-four explosions in the United Kingdom. Nine of these explosions, by which two people were killed and fourteen others injured, were properly boiler explosions, while the remaining twenty-five, killing seven persons and injuring fifteen others, were explosions of steam pipes, stop valves, drying cylinders, bakers' ovens, etc.

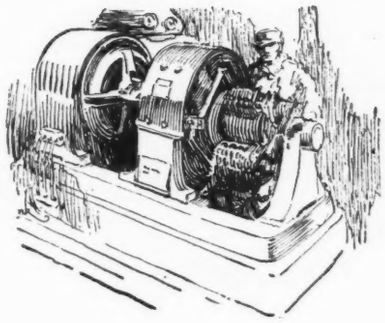
It would be interesting to compare the number of explosions in the United States during the same period if it were available. Former compilations have shown something like an explosion of a boiler proper for every working day in this country.

When each of the states has a boiler inspection department charged not only with seeing that the boilers under its jurisdiction are properly designed, constructed, installed and operated, but with the duty of investigating and placing the responsibility for failures, it will be possible to have some really reliable statistics, and the number of explosions will be materially less.

The designing of power plants is largely a balancing job. Efficiency, reliability and first cost are weighed against each other with a multitude of minor considerations shifting the pointer a little one way or the other. The best designers are men who combine technical and practical knowledge with unusual skill in the balancing and reconciling of a multitude of factors encountered in the laying out of a power plant.

Perhaps, as Professor Christie suggests on page 583, a few years will see the development of inexpensive materials which will make one thousand degree steam practicable in the power plant. As he points out, the resulting reduction in steam rates might actually lead to a lower plant cost per kilowatt.

Practical Ideas from Practical Men



WITH a view to stimulating engineers into the habit of recording for the benefit of brother engineers, unusual occurrences, how these were met and other practical expedients adopted in the operation of their plants, Power has decided to award two cash prizes each month during 1925. One of $25 for the best and another of $15 for the second best practical letter on plant operation or practical kinks received during the month. This is in addition to payment for the contribution at space rates. The winners for March will be announced next month.

Power is pleased to announce the awards of the judges for the first and second prize contributions received during February for this department in accordance with the terms of the contest as stated above.

The first prize of $25 goes to J. W. Pride, of Halifax, N. S., Canada, for his article on "Use of Carbon Fillers While Welding Makes Machining Unnecessary," in the March 24 issue.

The second prize of $15 goes to George S. Neeley, of Hartford, Ill., for his article on "Improvements Made in Ball-Thrust Bearing to Insure Positive Lubrication," in the March 31 issue.

The judges were: (Chairman) Willis Lawrence, mechanical engineer, Interborough Rapid Transit Co., New York City; Norman N. King, chief engineer, Singer Bldg., New York City, and D. L. Fagnan, formerly refrigerating engineer and more recently associated with the Smoot Engineering Corp., New York City.

Covering for Brine Fittings Made with Pitch and Ground Cork

A short time ago we had some brine pipes to cover, and the firm ordered the covering for the pipes, but neglected to get the coverings for a few fittings. So we ordered some brine putty from a local firm, but when it was delivered it was dry and like powder. Therefore we were stumped for a way to use it. We tried mixing it with various cements and paints, all of which proved unsatisfactory as it did not harden. Then we got some pitch such as roofers use and boiled that, at the same time stirring in the ground cork.

In the meantime we had built a form around the fittings, and when the mixture was at the right temperature so it would run nicely, we poured the molds. The next day when we removed the forms, we found a fine hard covering over the fittings. It was not necessary to use any wires, as the covering was cast in one piece. We put in enough cork to make a heavy, thick paste, and this had to be scraped from the pot with a knife.

As the pipes and fittings were dry and wire brushed clean, I see no reason why it should not be a good tight job and as good as a purchased cover.

Rochester, N. Y. R. G. SUMMERS.

Two-Phase Motors Operate Single-Phase

In our plant there are 150 motors of the squirrel-cage type ranging in size from ½ to 10 hp. and operating from a 220-volt three-wire two-phase power supply. One morning when about 100 of the motors were running, it was noticed that a 5-hp. elevator motor operated with a hum not common to this motor. When testing the fuses, it was found that the voltage on the two sides of the system was about 15 volts out of balance. In the afternoon another of the elevator motors started to operate with an unusual hum.

The motors in the plant are started and stopped several times a day, and as no operator complained about a lack of power, it was thought that the trouble was due to unbalanced voltage on the power system from which the motors were supplied. The main fuses, which are rated at 600 amperes, were not tested, since they were so much larger than any of the others in the plant that it was considered almost impossible for them to blow without some of the smaller fuses going out also. The five circuits that lead from the switchboard are protected with much lighter fuses and are only about five feet away from the main fuses.

About 6 o'clock, when most of the motors had been shut down, trouble started on the remaining motors on the system, which made it necessary to shut them down. The next morning they would not start. Tests with a lamp revealed that the neutral 600-ampere fuse was blown. After the fuse was renewed, conditions became normal in the plant and no further trouble was experienced with the power supply. It is therefore evident that about 100 two-phase motors had operated for eight hours on a single-phase power circuit without giving evidence of serious trouble other than a slight hum from two elevator motors. No doubt the other motors developed a hum similar to the elevator motors, but the noise of the shops prevented it from being noticed.

The explanation of the motors operating single phase is found in the fact that after a polyphase motor is brought up to speed, if it is connected to a single-phase circuit it will operate as a phase converter and will change the single-phase power into a system having the same number of phases as the motor. When the large number of motors were in operation, they had sufficient capacity to supply polyphase power for starting and to operate any motor two-phase that might have been heavily loaded; that is, lightly loaded motors would operate single-phase to supply two-phase power to the heavily loaded machines and keep the voltage of the system fairly well balanced. When there were only a

few motors in operation, the spare capacity in the system was not sufficient to take care of any abnormal condition that might develop and the motors began to act unsatisfactorily.

In passing it might be interesting to know that a system of operating polyphase motors from a single-phase power system has been used, where one three-phase motor was run on the system to convert the single-phase power into three-phase for operation of three-phase motors.

A. NARDUCCI, Electrician,
Homestead, N. J. Atlas Finishing Mills.

High-Pressure Boiler Saves in Heating Building

On taking charge of a business building devoted principally to the dress and coat industry, I found that the boiler room was equipped with a 500-sq.ft. cast-iron boiler for heating the building, also a 500-sq.ft. H. R. T. boiler to supply live steam at 70-lb. pressure to one tenant who had a cloth sponging and shrinking business.

Examination revealed that the cast-iron boiler had both of the rear sections cracked, the high-pressure boiler tubes were mere paper, the seams leaking, the water column actually set (upon accurate measurement) 8 in. too low. This was the reason the owner could never understand why the top row of tubes were a never-ending source of expense, always being renewed. The winter season had already begun, and tenants were complaining about not getting heat, and patiently waiting to condemn or praise the new engineer.

Upon the recommendation of some engineer friends I put two gallons of iron compound in the heating boiler in order to give heat to the building until I had a chance to get straightened out. To my surprise at the end of about three hours both sections had stopped leaking. Then it was found that there was no draft in the heating boiler, so that night I remained on the job and built an additional bridge wall on the back end of the grate bars which cut off about 6 sq.ft. of grate surface, but I found when it was completed that there was a real draft. For the time being it seemed that the heating troubles were over, but then the high-pressure troubles began.

The tenant who was using the 70-lb. steam signed a new long lease before I had taken charge of the building, and a new high-pressure boiler was recommended by the insurance company. I called up the owner and suggested that as he had to pay for a new boiler, why not get one large enough to heat the building and also supply 70-lb. steam to the tenant using it, at an additional cost of approximately $1,500.

To make it clear to the reader, the tenant using steam at 70-lb. pressure, actually upon measurement of water supplied to boiler, never required more than 150 sq.ft. of heating surface would supply. This plus 500 sq.ft. for heating the building would indicate that a boiler of about 750 sq.ft. would be required to make the plant one unit.

The owner gave his consent for the additional equipment, reducing valve, piping, low-pressure safety valves, return pump and minor accessories. Originally, both old boilers were equipped to burn pea coal and I had No. 1 buckwheat grate bars (dumping type) installed on the new boiler, so that the owner could get a return on his investment by burning a cheaper grade of coal. In the old installations combined, the requirements weekly were 6 tons of pea coal at $10.50 per ton, or $63. For the new installation, there is used 7 tons of No. 1 buckwheat at $6.25 per ton, or $43.75, showing a saving of $19.25 weekly or, roughly, $20. This saving in fuel consumption I attribute to both the cheaper fuel now burned and the difference in efficiency between a sectional and a return-tubular boiler.

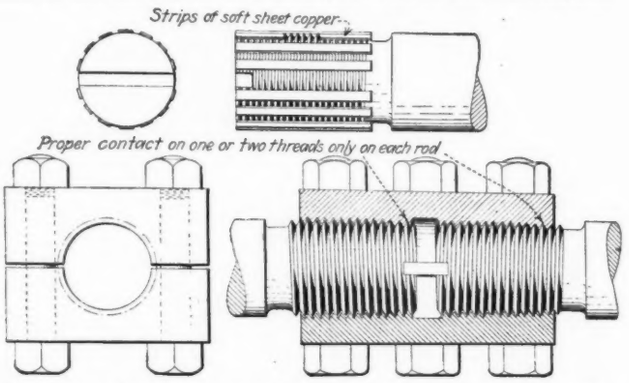
The additional cost of the larger boiler, $1,500, as can readily be seen, will more than pay for itself. For a 20-week heating season the saving at $20 per week would be $\frac{20 \times 20}{1{,}500}$ = approximately 26 per cent return on the additional investment of $1,500. Needless to mention, the old cast-iron sectional boiler is now held in reserve for use in case of emergency.

New York City. M. J. MURPHY.

How Piston Rod Was Tightened in Coupling in an Emergency

The accompanying sketch illustrates a defective piston-rod coupling of an air compressor. This coupling had become loose on several occasions, causing a bad knock, and required frequent tightening up.

At the first opportunity the coupling was taken apart to locate the cause of the trouble and it was found that several threads at the end of one rod and at the inner end of the thread on the other, as well as the corresponding threads in the coupling, were badly damaged. The evidence showed that one or two threads of each rod had been carrying practically all the load. Upon taking measurements of the threads it was found that the screw on the rod in the right-hand end of the coupling (as shown in illustration) was considerably smaller than the one in the left-hand end, thus causing the two halves of the coupling to make contact with the rod at two points only, as illustrated. As the compressor could not be stopped long enough to re-thread the rods or re-bore the one end of the coupling, a temporary repair was made by placing strips of softened sheet copper of suitable thickness on the thread of the smaller rod. The strips were stuck in place with lubricating grease, after which the halves of the coupling were clamped together, crushing the copper strips into contact with all the threads.



Copper strips were placed around one rod to compensate for difference in diameters

This was intended to be only a temporary repair, but it has been in use for over four years without showing signs of distress, so it has not been considered necessary to disturb it.

THOMAS C. PORTEOUS.
Michel, B. C., Canada.

Refinishing a Large Crankpin in Position

Some time ago, while overhauling a blowing engine, the crankpin was found to be badly worn and scored. To remove the fifty-ton flywheel and shaft would have been impractical even if the shop had been equipped to handle the work, and to remove the necessary material

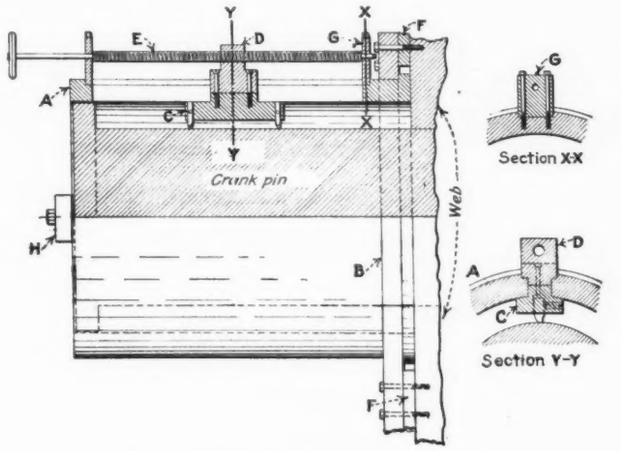


Fig. 1—Assembly of turning tool

from the pin with a file would have been a long, tedious operation, probably with unsatisfactory results.

To insure a quick job, the parts shown on the accompanying drawings were made and used with good results. Part *A* was made from a piece of extra-heavy pipe and part *B* from boiler plate. Block *C*, holding the tool, is fastened rigidly to block *D*, the two traveling parallel to the axis of the pin, in a machined slot and moved by the feedscrew *E*. The handwheel can be taken from an old valve.

In setting up the outfit, the sleeve *A* is slipped over the crankpin, followed by the holding piece *B*. Holes are spotted in the web for the capscrews, and after removing the holding piece, these holes are drilled and tapped. The holding piece is then replaced and fastened

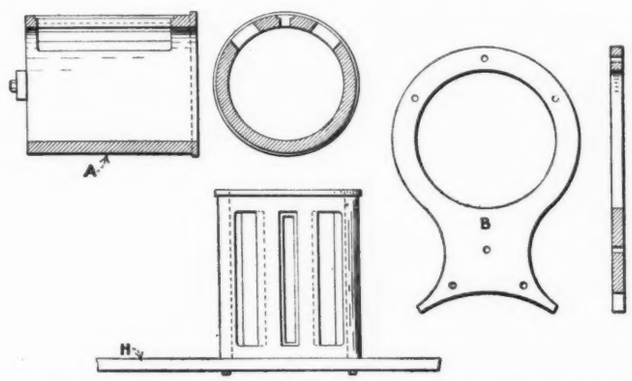


Fig. 2—Detail of turning sleeve and holding plate

to the web after inserting the filling pieces *F* at the top and bottom to prevent binding the sleeve. Block *C* is inserted through the handholes in the sleeve *A* and put in place under block *D* and rigidly fastened by the countersunk machine screws. The feedscrew *E* is then screwed through the block *D* and the end pieces *G* are slipped on and fastened to the sleeve by two small capscrews shown in section *XX*. After the handwheel and tool are put in place, the sleeve is lined up by moving plate *B* up, down or sideways as may be necessary. The holes in the plate for the capscrews should be made large enough to allow a slight movement for adjustment. The sleeve is held to the web by means of a shoulder bearing against the holding plate, and the tool is held in place by a safety setscrew.

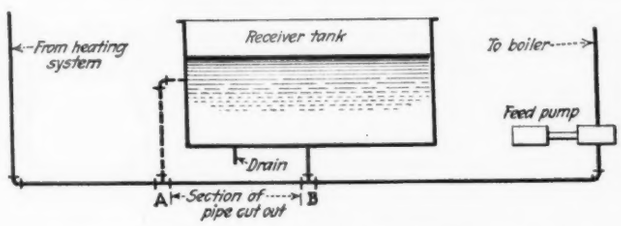
Although a motor drive may be arranged, the apparatus is easily turned by two men, one on each end of a double-ended lever *H*. The feed can be made automatic by fastening a weight, heavy enough to prevent turning, to the handwheel or feedscrew. Care must be taken to have the inside and outside diameters of the sleeve agree with the diameters of the pin and holding piece in order to have a good bearing surface and prevent chattering. Block *C* holding the tool must also be made long enough to pass under the inner end of the bushing a sufficient distance to machine the entire length of the pin.

This method of turning large crankpins is not new, but the arrangement and detail of the apparatus will probably be of interest to engineers who have not built such a machine or had occasion to plan the details themselves, as it has not the widespread use and application that its simplicity and ease of operation should warrant. Dimensions have been omitted from the sketch to facilitate its adaption to any dimensions which may quickly be taken from any particular crankpin.

Clarkdale, Ariz. RICHARD H. MORRIS.

Changing Connection to Receiver Tank Keeps Oil Out of Boiler

In using exhaust steam for heating in our building, we got considerable oil in the boiler. The return line



Change made in return line connection to tank

from the heating system passed directly under the receiver tank to the feed pump, as shown by the full line in the sketch. A float in the receiver tank is connected with a pump governor to control the operation of the pump and keep the water in the tank at a certain level. Each time the pump started, it would draw water directly from the heating system instead of from the tank, and in this way any oil contained in the water was passed into the boiler.

To remedy this trouble, I made the changes indicated on the drawing. The section of pipe from *A* to *B* was cut out and the return inlet to the tank made at a point on the side, as indicated by the dotted line. Now all the water and oil goes into the tank before passing to the pump. This allows the oil to separate from the water and float to the surface, which prevents its getting into the boiler. The tank is drained and cleaned at regular intervals. NELS HILSEN.

Duluth, Minn.

Comments from Readers

Bypass Improves Operation of Vacuum Pump

I read with interest the article, "Bypass Improves Operation of Vacuum Pump," in the Feb. 17 issue, as I had just such a source of trouble to overcome. The return pump on the heating system is located in the basement of the power house, the suction pipe being placed in a 4x6-ft. tunnel under the basement floor. The tunnel extends outside of the building and connects with another tunnel about 1,000 ft. long in which all the drains from the radiators of a great many buildings are connected to a common header or suction line. The suction pipe is about four feet below the suction opening of the pump, which is a disadvantage when handling hot water.

In cold weather, with a steam pressure in the main line of one or two pounds, it was impossible to maintain a steady vacuum on the pump. The pump was run above normal speed to overcome the suction lift, but could not be depended upon to take care of the drains if the water was very hot. When the water reached a certain temperature the pump would lose its suction and would race until the water in the suction cooled down. It would then take water and get back to a normal speed and carry around 15 in. vacuum. During the time the pump was racing, there was no circulation in the heating system and complaints from the tenants of the buildings were not infrequent.

The trouble was finally overcome by making a ½-in. pipe connection on the suction pipe close to the pump and supplying a small amount of cold water to the suction at this point. The water supplied from a storage tank at a pressure of about 14 lb., one turn open of a ½-in. valve being sufficient. The speed of the pump has been reduced about 50 per cent, and a steady vacuum of 10 in. can now be maintained regardless of how hot the water may get. THOMAS PASCOE.

Norway, Mich.

The Engineer's Position in the Manufacturing Plant

In every kind of manufacturing works there is always to be found an engineer who is responsible for keeping the machinery moving. Some of these have a great deal of responsibility while the salary is exceptionally low; others lead a sort of cat and dog life and are a good mark for all the blame and the kicks that are continually on tap.

In some cases I have known, the engineer has grown up with the business. At the start, he was the only man in his department, but others followed until he became responsible for a dozen men or so, still remaining, however, a sort of working foreman. "Working" is the correct term, as he is often required to carry on far into the night so that everything may be all right in the morning. In fact, he carries the whole responsibility for this side of the business without any credit for so doing.

There are many engineers in such positions, and while they have my sympathy, I cannot, after many years' experience in this work, help thinking that they are much to blame for such a state of affairs and that the position is, to a great extent, what they make it. Before taking up a situation of this sort, there is much to consider. First is the fact that often there is no one connected with the business who knows anything about engineering, and from the proprietor down the power plant is considered a necessary evil and every cent expended on it is money wasted. Often, we find, especially if the concern has been a considerable time in business, a ramshackle old plant whose funeral is long overdue. In such a position the engineer will find, at least for a time, anything but a bed of roses. The engineer in a plant of this sort, unless he is a strong man with confidence in himself and his ability, may bid good-by to most of the joys of life, but for the strong man it may provide many happy hours and prosperous times.

A few days ago I called on an old friend who is chief engineer at some large flour mills, and from an arm chair in his office, smoking one of his cigars, I heard his story.

Twenty years ago, when taking up his present position, he found the plant in a bad state of repair. His predecessor had been one of the sort that hid himself with fear and trembling whenever the "old man" was on the premises, but my friend, according to his own story quickly reversed this process and the "old man" did the dodging trick. Co-operation was finally established, however, and the results that followed made a big reduction in operating costs.

The first move was the replacing of two old waterwheels with modern turbines, the starting up of which made possible the shutting down of an engine and two boilers, and the saving in coal alone paid for the whole outfit in four years. Today they have the most modern machinery, both for power and milling, and the fine house my friend got built for his own use is also up-to-date, the cost of it being saved from improvements in one process he introduced. He has organized a staff of assistants, and judging from what I saw, his real position is general manager of the whole concern.

He does not claim anything wonderful in all this, any man can do it, but without doubt he is one who considers his profession as something to live up to. In my opinion his success really came from knowing much more about power-plant problems than anyone else there, when he took the position. Since then, he has taken great pains to retain that position by the careful study of all new ideas as they come along, which is what we all can do, and by so doing, prove that the plant engineer's job can be something worth having and holding. F. P. TERRY.

Belfast, Ireland.

Humidity and Coal

Occasionally, we see the general statement, sometimes on apparently good authority, to the effect that a saving of coal can be made by raising the humidity of the air in the buildings to be heated. It is usually well known that when cold air, even when saturated with moisture, is heated, it becomes dry, that is, has low humidity. In the heated state the water vapor it contains, owing to its previously saturated condition, represents only a fraction, perhaps 25 per cent, of the amount of water vapor it will carry before precipitating any. In other words, air of 100 per cent humidity at 30 deg., when heated to 70 deg., though carrying the same weight of water vapor as before, will have a humidity of about 30 per cent. The colder the initial condition the lower the final humidity.

For comfort of human beings the humidity should be about 50 per cent at 70 deg. The statement referred to, usually takes the form that 65 to 68 deg. properly humidified, is more comfortable than 70 or 72 deg. with low humidity. From this the inference is made that less heat is required to maintain the former condition.

To heat 1,000 cu.ft. (75 lb.) of air from 30 to 75 deg. requires about 720 B.t.u. If saturated at 30 deg., the humidity will be 30 per cent at 70 deg., and 0.35 lb. of water vapor will have to be added to bring the humidity up to 50 per cent. Heat from somewhere has to be supplied to obtain the water vapor, and at the rate of 1,060 B.t.u. per pound of water evaporated, $0.35 \times 1{,}060 = 370$ B.t.u. Neglecting small corrections for changes of volume, specific heat of the vapor, etc., it is seen that to heat and humidify the air takes about 50 per cent more heat than that necessary merely to raise the temperature of the cold air to 70 deg. F.

This, of course, applies only to the air as taken from the outside and not to that which is re-circulated around the heating coils, so it is only the air change (leakage, infiltration, etc.) that is figured as shown in the previous paragraphs. The percentage of the total heat that is required by the air change varies widely with different buildings and conditions. In a factory where a large amount of air is exhausted by dust or fume collectors, it may run up to 90 per cent, in which case all the air that is heated is taken directly from the outside.

My experience covers no cases where coal could be saved by raising the humidity of the air, but, like all engineering problems, each set of conditions calls for a somewhat different answer, and I may yet meet one. In most cases that I have figured, the temperature could be raised to 75 deg. or higher before the increased losses would equal the additional amount of heat required to raise the humidity to the desired point.

Health conditions, special manufacturing processes and storage of goods that deteriorate under low humidity conditions, in many cases make humidifiers good investments.

The dew point of air at 70 deg. temperature 50 per cent humidity, is about 50 deg., which means that single-pane windows, and sometimes walls, will "sweat" if the outside temperatures get much below that. The inside surface of the pane of glass is somewhat warmer than the outside, depending upon the thickness of the glass. When "sweating" starts, no doubt the heat losses are greater than would be the case with low humidity.

Bird ("Transactions A. S. M. E.," 1915) says that the tension of leather belts is increased about 50 per cent with a drop in humidity of from 90 to 20 per cent.

Humidity has its merits and can stand upon them, but I think that an attempt to invest it with one for coal saving should be examined in every case before we demand that the poor firemen really burn less coal after we get the humidifiers into operation.

Toledo, Ohio. J. R. BELKNAP.

High Steam Temperatures

Engineers now consider 700 deg. F. as a safe limit for initial steam temperature, although some are venturing to use temperatures as high as 750 deg. These limits are imposed by the materials at hand for the construction of superheaters, piping, valves and turbine parts. The steels now used decrease rapidly in ultimate strength after 750 deg., and at that temperature the elastic limit has decreased to about two-thirds its value at ordinary room temperature. With a definite limit set to temperatures, engineers have turned their attention to the use of higher boiler pressures and reheating between stages in an attempt to secure better station economy.

The processes of combustion have been so fully developed recently that little further gain can be expected from improved furnace and boiler performance. Hence the possibilities of the various steam cycles are being studied closely, and future developments will be based on improvements in the operating cycle to which the steam is applied. This will undoubtedly result in the more general use of higher steam pressure.

High steam pressures and reheating result in decided gains in the operating cycle, as has been clearly shown in many recent papers. But boilers and other equipment for these conditions are costly, and this added cost offsets to a certain extent the economy of the cycles.

These considerations suggest the possibility of using higher steam temperatures at the pressures now in use. Boilers and auxiliaries are fairly well standardized up to about 415 lb. gage pressure and can be bought on a competitive basis. Furthermore, it would be interesting to know whether the economy of plants now in operation could be improved by raising the steam temperature.

The possibilities of higher steam temperatures may be illustrated by the following example: The water rate of a large steam turbine at best load with 375 lb. gage at throttle, 700-deg. temperature and 29-in. vacuum may be assumed as 9.5 lb. of steam per kilowatt-hour. A similar turbine under the same conditions of pressure and vacuum but designed for steam with 1,000 deg. initial temperature would probably require 7.5 lb. per kw.-hr. This can be interpreted in either of two ways. Only 80 per cent of the capacity of standardized boilers may be installed for a given output with high-temperature steam, or 25 per cent more generating capacity may be installed for a given capacity of boiler plant. Boiler-feed pumps, heaters, evaporators, storage tanks, condensers, condenser auxiliaries, etc., could be considered in the same way. This would result in a low unit cost for this equipment when high steam temperatures are used. It is not a difficult matter to locate a superheater to give 1,000 deg. temperature if suitable materials are available.

These savings will be offset by the higher cost of additional superheater surface and of piping, valves and turbine to stand the temperature of 1,000 deg. At the present time no such material is available. The development of metals that can be used under high temperatures is receiving much study. Mr. McDermet in his article in the Dec. 23, 1924, issue stated that one may expect satisfactory materials at commercial cost to be available within the next year that will permit steam temperatures being raised from 750 to 950 deg. A recent editorial in a leading British engineering journal discussed the possibility of developing workable materials of reasonable cost that might even be used up to 1,300 deg. and pointed out that it was quite reasonable to expect that metals will soon be available to cover at least a greater part of this range.

The use of such high superheat would also result in marked savings in fuel. The adoption of these higher temperatures is conditioned on the development of materials and their cost. The cycle warrants close study of such metals and may even ultimately result in a lower cost station than can be secured by the use of high pressures with the present limits of superheat.

Baltimore, Md. A. G. CHRISTIE.

Physical Side of Concentration in Boilers

I read with great interest the article in the Jan. 6, issue, entitled "The Physical Side of Concentration in Boilers," by R. W. Andrews.

The engineering firm with which I am connected is the district representative for a large manufacturer of several types of water softeners, including the zeolite and the lime and soda ash softeners, both hot and cold process. Frequently we are asked to submit recommendations on water-softening equipment for boiler-feed purposes, and as we are in a position to offer either type, we usually recommend the type that in our opinion is most suitable for the particular installation under consideration.

Just recently, we were consulted on one of these matters by a concern that wished to treat a total of approximately 3,000 gal. per hour. The water to be treated was hard well water, and they were undecided as to which type, zeolite or chemical, should be installed. We accordingly prepared the accompanying chart on boiler concentration and also gave them the following tabulation which embodies the analysis of the raw well water, the analysis (estimated on basis of other tests made) of the water after treatment by hot process lime and soda ash softener and also by the zeolite method:

Incrusting and Corrosive Solids	Content in Grains per U. S. Gal. in— Raw Water	Hot Process	Zeolite Treated
Calcium carbonate	11.86	1.00	0.50
Magnesium carbonate	5.65	0.21	0.21
Magnesium sulphate	3.90	....	....
Silica	0.87	0.87	0.87
Total incrusting solids in grains per gal	22.28	2.08	1.58
Non-incrusting solids			
Sodium carbonate	....	1.59	18.92
Sodium sulphate	1.14	5.76	5.76
Sodium chloride	1.71	1.71	1.71
Total non-incrusting solids	2.95	9.06	26.39
Tota solids	25.13	11.14	27.97

Hardness in water in equivalent calcium carbonate ($CaCO_3$)	
In rawwater	21.86
In hot process treated water	1.25
In zeolite treated water	0.75

This plant had about 25 per cent return condensate and 75 per cent raw water makeup, either treated or raw. We naturally recommended the hot-process softener system, as from the tabulation it will be noticed that the total incrusting and corrosive solids would be reduced to a negligible amount the quantity remaining would be almost the same with the hot-process as with the zeolite method. This also applies to the total remaining hardness in terms of $CaCO_3$.

The important item, however, is the total solubles in the form of various salts still remaining in the water after treatment. These, it will be noted, are only 11.14 grains per gallon for the hot-process treated water as compared with 27.97 grains for the zeolite treated water.

As Mr. Andrews mentions in his article, it is this element of total solids that still remain in the water, that causes concentration of these salts in the boiler to a point where priming occurs unless a given fixed amount in proportion to the total water fed to the boiler, is blown down at regular intervals and replaced with either treated, raw or condensate water.

With the hot-process softener the principle involved is to free the carbonic acid (CO_2 gas) by action of heat and chemicals, and as this acid is the medium that holds the various incrusting and corrosive carbonates in solution, they cannot remain in solution when this CO_2 gas is set free. Hence they precipitate and are carried away with the sludge. The zeolite, on the other hand, does not remove or set free the CO_2 gas as it works on the exchange base principal, changing the base of the carbonate and sulphate incrusting solids over into non-incrusting solids in solution, which therefore still remain as solids in solution which will not precipitate and accordingly cannot form scale.

In order to illustrate the effect of concentration in the boiler and the quantity of blowdown required to maintain a given maximum concentration, when feeding a water containing a given or fixed quantity of non-incrusting solids, the accompanying chart was prepared.

The chart shows the maximum saturation point of non-incrusting solids in boilers, when the feed water contains a given constant quantity, in grains per gallon, of non-incrusting solids. Also the amount of blowdown per hour, in proportion to the total quantity of water fed to the boiler per hour, as well as the holding capacity of the boiler and percentage of blowdown to this holding capacity necessary to maintain the amounts of concentration per gallon given at the bottom of the chart.

When a boiler is first filled, the concentration is only the equivalent to that of the feed water. As the water is evaporated and feed water of the same original concentration is added to replace the evaporation, the concentration in the boiler naturally increases progressively until a point in saturation is reached where excessive priming would occur. Before excessive priming does occur, a careful boiler operator will blow down a portion of this concentrated water and replace it with regular feed water containing proportionately less solids.

In the process of blowing down and then adding treated water to replace the blowdown, as well as adding treated water for the regular boiler feed, the concentration in the boiler even with a constant fixed amount of blowdown each hour, progressively increases to a point where the grains per gallon content multiplied by the number of gallons blown down, will exactly equal the number of grains total of non-incrusting solids delivered to the boiler each hour. This then is the point that is referred to on the chart as the "maximum saturation point."

Applying the chart to the conditions in connection with the proposed installation referred to in early part of this letter, we would refer to the analysis tabulation and the item therein giving the total non-incrusting solids remaining in the water after treatment or softening. The zeolite treated water would contain, say, 28 grains per gallon; the makup would be, as already referred to, 75 per cent of the total feed water; the total solids in the feed water would then be 0.75×28, or 21 grains per gallon.

Assuming that it would be possible to operate these boilers satisfactorily with a maximum concentration of 300 grains per gal. and the blowdown was to be in the water. On this basis, assuming that 150 grains were the maximum allowable concentration with 21 grains per gal., total solids in the feed water (zeolite treated), it would require a blowdown (see chart) each hour equivalent to 15 per cent of the total water fed to the boiler each hour.

It should be borne in mind that there is a limit to the quantity or percentage of the holding capacity of a boiler which can be safely blown down and still maintain constant and reliable operation. The boilers in this case, as stated previously, were Stirling class "A" in which I believe that the allowable limit is something like 5 to 6 per cent of the holding capacity,

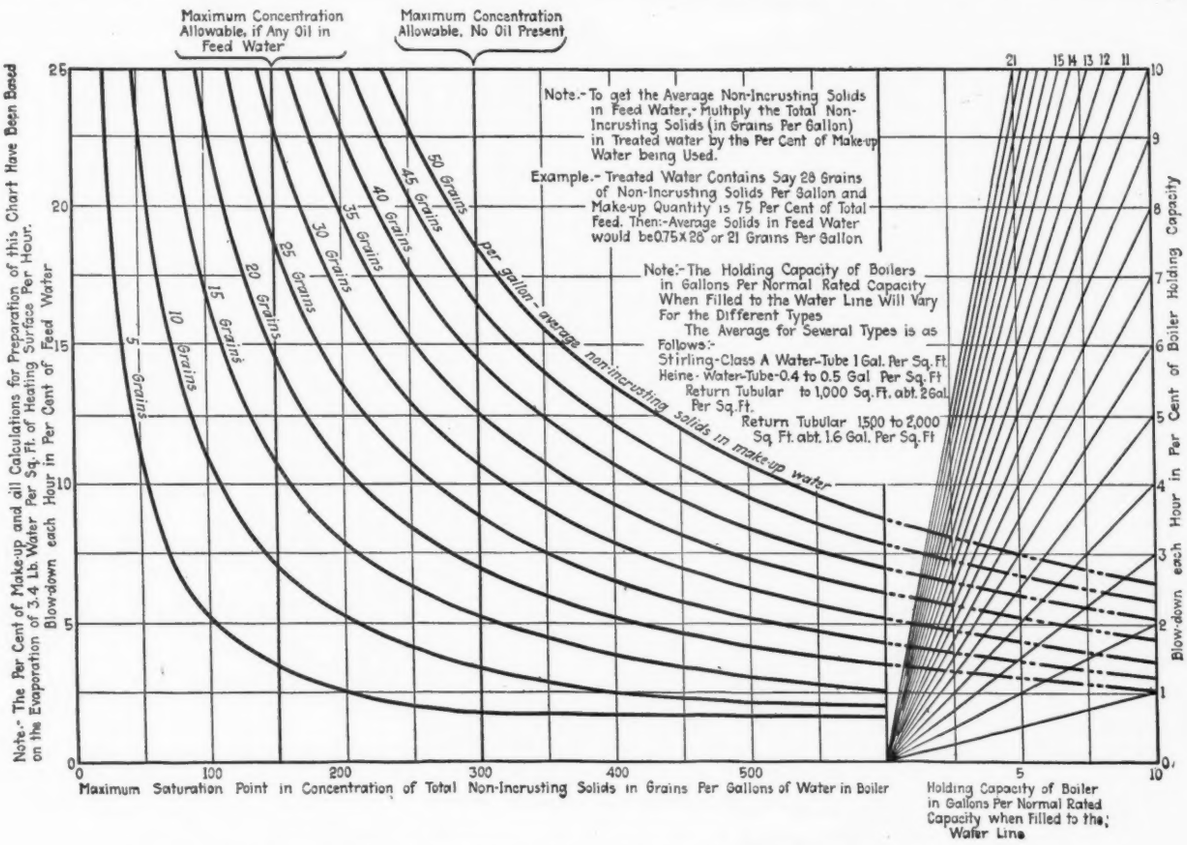

Maximum Concentration Allowable, if Any Oil in Feed Water
Maximum Concentration Allowable, No Oil Present
Note:- To get the Average Non-Incrusting Solids in Feed Water,- Multiply the Total Non-Incrusting Solids (in Grains Per Gallon) in Treated water by the Per Cent of Make-up Water being Used.
Example.- Treated Water Contains Say 28 Grains of Non-Incrusting Solids Per Gallon and Make-up Quantity is 75 Per Cent of Total Feed. Then:-Average Solids in Feed Water would be 0.75×28 or 21 Grains Per Gallon
Note:- The Holding Capacity of Boilers in Gallons Per Normal Rated Capacity When Filled to the Water Line Will Vary For the Different Types
The Average for Several Types is as Follows:-
Stirling-Class A Water-Tube 1 Gal. Per Sq. Ft.
Heine - Water-Tube-0.4 to 0.5 Gal Per Sq. Ft
Return Tubular to 1,000 Sq. Ft. abt. 2 Gal. Per Sq. Ft.
Return Tubular 1,500 to 2,000 Sq. Ft. abt. 1.6 Gal. Per Sq. Ft
5 Grains
10 Grains
15 Grains
20 Grains
25 Grains
30 Grains
35 Grains
40 Grains
45 Grains
50 Grains
per gallon - average non-incrusting solids in make-up water
21 15 14 13 12 11
Note:- The Per Cent of Make-up and all Calculations for Preparation of this Chart Have Been Based on the Evaporation of 3.4 Lb. Water Per Sq. Ft. of Heating Surface Per Hour.
Blow-down each Hour in Per Cent of Feed Water
Blow-down each Hour in Per Cent of Boiler Holding Capacity
Maximum Saturation Point in Concentration of Total Non-Incrusting Solids in Grains Per Gallons of Water in Boiler
Holding Capacity of Boiler in Gallons Per Normal Rated Capacity when Filled to the Water Line

Chart showing maximum saturation point of non-incrusting solids in boiler, when feed water contains given amount of solids per gallon

regulated so that this concentration would never be exceeded, it will be noted that if you read upward on the chart from the 300 grain maximum concentration point, to the point where it intersects the 21 grain curve, and then to the left, it will be found that the amount of blowdown each hour necessary to maintain this 300-grain concentration and prevent it from increasing would be 7¼ per cent of the total water fed to the boiler each hour. Also, when reading to the right (as these are Stirling boilers with a holding capacity of about 1 gal. per sq.ft. of heating surface) it will be found that about 3 per cent of the holding capacity of the boiler must be blown down each hour.

Another matter to consider is the possibility of getting a small amount of oil into the boiler through the return condensate. This is particularly prevalent where the condensate is collected from steam used in reciprocating machinery. A small amount of oil may cause priming with a concentration of not over 150 grains per gal., depending upon other elements present which on the basis of 10 gal. per normal rated capacity of the boiler would represent from 12½ to 15 per cent of the total feed water if blown down each hour to the maximum limit. Boilers having a lesser holding capacity per normal rated capacity of output would concentrate more rapidly and would necessitate more frequent blowdowns as the amount or proportion of the amount blown down to the holding capacity of the boiler would be about the same—that is 5 to 6 per cent of the holding capacity—and the holding capacity being less, more frequent blowdown would be required.

The question of boiler blowdowns and the enormous losses in heat units will, the writer feels sure, receive more consideration in the future. This applies to the concentration and priming question as well. Mr. Andrew's article appearing so shortly after I had spent some time in the preparation of the chart, brought forth the idea that possibly the readers of *Power* might be interested in the foregoing analysis.

Cincinnati, Ohio. W. A. BECKER.

Questions and Answers

Conducted by

Franklin Van Winkle

Testing Tightness of Boiler Rivet

How can a hammer test be made to test the tightness of a boiler rivet? *R. C.*

To test the tightness of a rivet, place the thumb against one side of the rivet head and the forefinger of the same hand on the plate. Then any looseness of the rivet can be felt when the rivet head is struck a sharp blow with a sounding hammer in the other hand.

Six Tons per Twenty-four Hour Equivalent to One Gallon of Water Per Minute

What constant would be used as a multiplier for conversion of U. S. gallons of water discharged per minute into tons of 2,000 lb. discharged per 24 hours? *L. C.*

One U. S. gallon of water at the temperature of 62 deg. F. weighs 8.3356 lb. If the flow is at the rate of one U. S. gallon per minute, it would amount to 8.3556 $\times$ 60 $\times$ 24 = 12,003.264 lb. of water in 24 hours and therefore would be equivalent to flow at the rate of 12,003.264 $\div$ 2,000 = 6.001, or roundly 1 gal. per min. = 6 tons per 24 hours.

Charging Air Chamber When Suction Pressure Is Above Pressure of Atmosphere

Where the suction pressure of a triplex pump is 45 lb. gage, how can the air chamber be charged with air? *T. P.*

When compressed air is available at sufficient pressure, it is preferable to charge the pump air chamber by direct injection of the air. When the suction pressure is above the pressure of the atmosphere, an air-charging device similar to that described and illustrated, page 35, Jan. 6 issue, for free air, may be employed, but in place of free air there must be a supply of compressed air above the pressure of the suction water. The compressed-air supply then should be throttled nearly to the suction pressure, so the glass gage on the air charging device will indicate that the compressed air is not discharged into the pump suction chamber.

Setting Valve of Single-Valve Engine

How is the valve set on a single-valve automatic engine to obtain equal cutoffs, and why is it necessary in valve setting to block out the governor to middle position? *O. F. B.*

With the governor in proper adjustment the only additional adjustment of the valve gear consists in adjusting the length of the valve stem or some connection between the governor and the valve, to obtain equal cutoffs for some position of the governor. The valve setting cannot give equal cutoffs for more than one particular load. Hence the cutoffs are equalized by adjustment of the valve stem or connections when the governor is blocked out halfway to secure the best compromise; or if the average running position is known, the cutoffs may be equalized for that position. When the cutoffs are the same, the crank end may have less lead than the head end, and when this is the case the lead on the head end should be decreased by adjusting the length of the valve stem to obtain proper lead for the crank end.

Cleaning Water Gage Glass in Place

How can the water gage glass of a boiler be cleaned of stain without removing the glass from the fixture? *T. W.*

At a time when there is only about 5 lb. pressure on the boiler, draw three-fourths of a cupful of warm water from the gage glass and to it add about one-third the quantity of muriatic acid. Close both water gage valves, open the pet-cock at the bottom and blow the water out of the glass by opening the top water gage valve. As soon as the glass is empty of water, again close the top gage valve and raise the cupful of the acid solution to submerge the end of the pet-cock. Condensation of the steam in the gage glass will cause the solution to rise in the glass. Keep the pet-cock submerged and by slightly opening and closing the top valve, the cleansing solution can be alternately drawn into and expelled from the glass. Care must be taken that the acid solution is not splashed into the eyes or over the face or hands of the operator.

Rise of Boiler Pressure from Heat of Setting

Recently, one of our boilers in a battery with others carrying 100 lb. gage pressure was cut out. The fires were drawn and the feed pump left running, supplying feed water at the temperature of about 180 deg. F. In a few minutes the pressure rose to 118 lb. when the safety valve opened, but when it closed the boiler pressure rose again until the feed pump was stopped and then the pressure quickly fell to 100 lb. Could the rise of boiler pressure be due to operation of the feed pump? *J. H. E.*

The rise of pressure undoubtedly was due to radiation of heat from the walls of the boiler setting. At the time the feed pump was in operation, the feed water at lower temperature than the boiler water had a tendency to reduce the pressure, and at the same time the heat of the setting was sufficient to increase the boiler pressure. Finally, the boiler and setting cooled sufficiently for the pressure to drop back to 100 lb., and as the feed pump was stopped at the same time, the impression may have been obtained that pressure above 100 lb. was due to operation of the feed pump.

A new slant on things observed in and out of the power plant

What Happens and Why?

Principles of CO_2 Instruments

THERE are many instruments on the market for automatically determining the percentage of CO_2 (carbon dioxide) in flue gases, the purpose

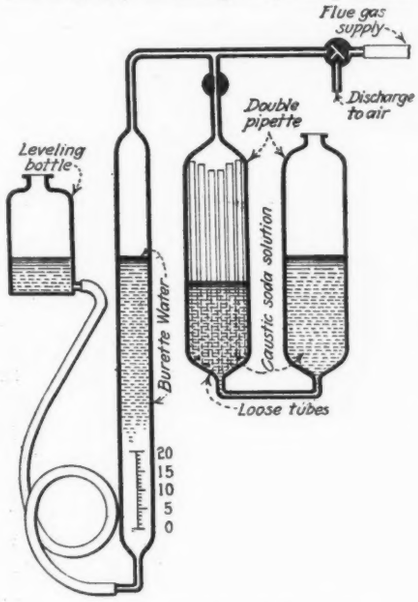


Fig. 1—Elements of the Orsat apparatus

of all of these being to enable the boiler operator to reduce the biggest boiler loss, that due to the sensible heat of the flue gases. The heat lost up the stack when burning a given weight of fuel depends on the weight of flue gas produced and its temperature.

A high percentage of CO_2 does not mean that an abnormally large weight is produced per ton of coal. In fact, a ton of coal always produces the same weight of CO_2 regardless of how the boiler is operated, excepting only the slight variations that occur due to the production of CO and the loss of carbon in the ash. A low percentage of CO_2 simply means that more excess air is mixed with the flue gases, so that the same weight of CO_2 is a smaller percentage of the total. If it were possible to cool the flue gases down to room temperature, this excess air would represent no loss, but at customary flue temperatures there is a substantial loss.

Of the automatic machines on the market some are indicating only, while others both indicate and record. The purpose of this article is not to describe the actual mechanical details of construction, but to indicate, by simplified diagrams, the principles upon which most of them operate.

One class of CO_2 machines—including instruments differing greatly in details of design and construction—is based on the so-called "Orsat," a hand-operated portable instrument for the analysis of flue gas. Therefore the description of a simple Orsat will cover the principles involved in all such instruments, although the mechanism required for automatic operation may give them a very different appearance.

The fundamentals of the Orsat, where only CO_2 is to be determined, are covered by Fig. 1. The three essential elements, aside from the connections, are a burette for measuring the volume of the original gas sample and its volume after the CO_2 has been removed, a leveling bottle for drawing flue gas from the supply into the burette, from the burette into the pipette, etc., and a double pipette containing a caustic-soda solution for absorbing CO_2 from the flue gas.

At the start the caustic-soda solution fills the front half of the double pipette up to a scratch in the neck, the cock above being closed. By manipulating

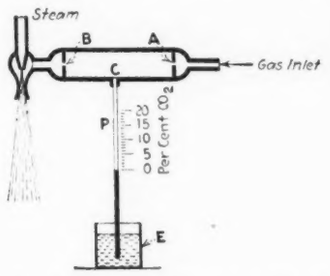


Fig. 2—Orifice instrument with chemical absorption

the leveling bottle and the three-way cock, a supply of gas is drawn into the burette, just reaching to the zero mark on the scale at the bottom. The burette then contains 100 parts of gas by volume. By means of the leveling bottle the gas is then pumped into the double pipette, displacing the caustic soda to the back branch. This displacement exposes the wet tubes, which quickly absorb the CO_2 from the gas. By means of the leveling bottle the gas minus the CO_2 is withdrawn from the pipette until the liquid again reaches the scratch in the neck, after which the gas volume is measured in the burette. The reading on the scale gives directly the percentage of carbon dioxide. During all measurements in the burette the bottle is so held that the water level in the bottle is the same as in the burette.

Some of the automatic instruments based on this principle manipulate the bottle and cocks by clockwork, but more of them secure the same effect by the flow of water or mercury through ingenious arrangements of tubing and measuring bulbs. The liquid caustic-soda solution is frequently replaced by a carton of dry caustic soda which acts in the same way.

Fig. 2 illustrates the principle of an automatic instrument making use of chemical absorption, but using orifices rather than a bulb to measure the volume of the gas before and after absorbing the CO_2. The steam aspirator draws the gas through two identical orifices, *A* and *B*, located in series. If there is no CO_2 in the gas or if no provision is made to absorb it, the pressure at *C* will be halfway between that in the gas entering *A* and that in the gas leaving *B*, since the pressure drop across one orifice must be the same as that across the other, the diameters and flows being the same in both cases. If, however, a carton of caustic soda is inserted between the two orifices, and if the gas contains CO_2, the volume of gas passing through *B* will be less than that entering *A*, by the amount of CO_2 present. This being the case, the pressure drop across *B* will be less than that across *A*, but the total drop across *A* and *B* combined will be automatically kept the same as before. As a result, the pressure at *C* will be reduced and the liquid in the

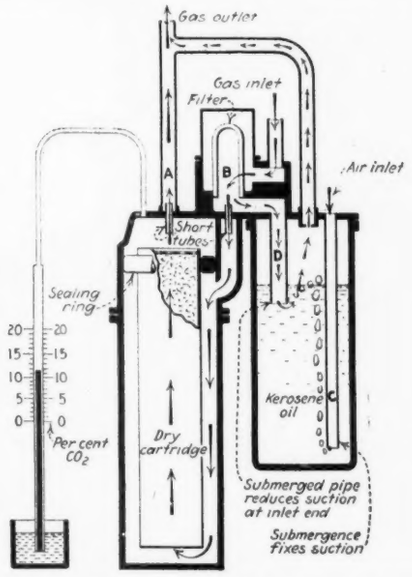


Fig. 3—Similar to Fig. 2 but with short tubes instead of orifices

tube *P* will rise a distance proportional to the amount of CO_2. This percentage can be read directly on a properly graduated scale.

The actual instrument makes provision for maintaining a constant pressure at the entrance of *A* and the exit

of *B*. It also provides for filtering and cooling the gas.

Fig. 3 shows another instrument almost identical in principle, in which short tubes replace the orifices. The pipes *D* and *C*, by their submergence beneath the surface of the oil, definitely

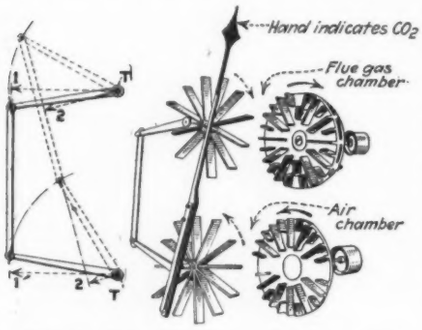


Fig. 4—Instrument worked by greater density of CO_2

fix the pressures at the entrance to the tube *B* and the exit to the tube *A*. Between these two is placed the carton of caustic soda, and the connection to the manometer which reads the percentage of CO_2.

A CO_2 machine may be built to operate upon any property of the flue gas, physical or chemical, which varies with

Fig. 5—Three Wheatstone-bridge arrangements for electrical CO_2 instruments

the amount of CO_2 present. For example, CO_2 is about 50 per cent heavier than air, the other constituents of flue gas being practically equal to air in weight. The greater density of CO_2 is made use of by the instrument which is shown diagrammatically in Fig. 4. This has two chambers, each containing a fan rotated at constant speed by a motor and a bladed wheel which is given a tendency to turn by the rotating mass of gas or flue gas. These

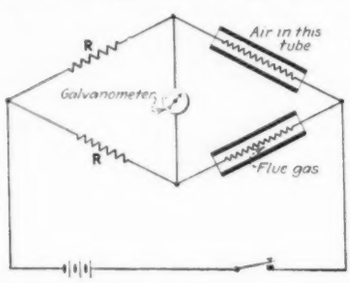


Fig. 6—Electrical recorder corresponding to first arrangement of Fig. 5

wheels tend to turn in opposite directions. As shown by the sketch at the left, the two turning moments are balanced against each other by a connecting link. As the link moves the lever arm of one increases and the other decreases, so that for any ratio between the two turning effects there is but one position in which the mechanism will balance. The turning effect is always greater in the chamber containing flue gas, on account of the greater density of CO_2, thus the pointer scale may be graduated to read CO_2 directly.

A third class of CO_2 instruments is electrical and operates on the principle that CO_2 is a better conductor of heat than the other constituents of flue gas. Thus, if two exactly similar wires are immersed, one in flue gas and one in air at the same temperature and pressure and with the same humidity, the wire immersed in the flue gas will radiate its heat more readily and will thus be at a lower temperature. With most metals change of temperature produces a marked change in electrical resistance. Any device capable of measuring this change in resistance can be calibrated to read in percentage of CO_2.

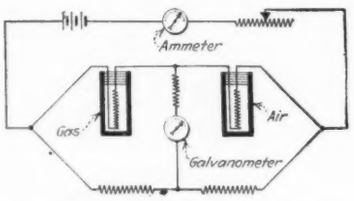


Fig. 7—Electrical recorder corresponding to second arrangement of Fig. 5

Most instruments of this type make use of the well-known Wheatstone bridge. Three possible arrangements are shown diagrammatically in Fig. 5. When the resistance in all four arms is equal, there is no tendency for the current to flow through the cross-connection and the galvanometer and the

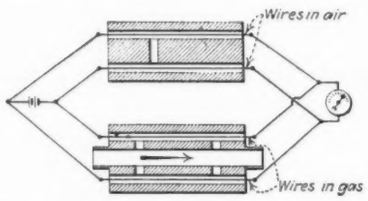


Fig. 8—Electrical recorder corresponding to third arrangement of Fig. 5

bridge is said to be "balanced." If the resistance in any of the four arms changes, this balance is broken and some of the current flows through the galvanometer, which can be calibrated to indicate the amount of change in resistance.

In the three diagrams the letter *R* indicates a constant resistance, "*air*" indicates that the wire is immersed in air, and "*gas*" indicates that it is immersed in the flue gas, provision being made to have the flue gas and air at the same temperature and pressure and the same humidity. It is evident that in any of the three arrangements shown a variation in the percentage of CO_2 will change the resistance in the arm of arms marked "gas" and thus unbalance the bridge. The first type shown is represented by Fig. 6, the next by Fig. 7, where the outside ammeter and variable resistance are introduced to permit maintaining a constant current through the bridge, and the third by Fig. 8. At first glance the connections in Fig. 8 seem to differ from those shown in the right-hand diagram of Fig. 5, but a little study will show that they are exactly the same.

Space is lacking to outline still other principles that have been used in the construction of CO_2 instruments. For example, an instrument has been constructed based on the optical principle that a hollow glass prism filled with flue gas will deflect light more when the gas contains CO_2. It is probable that in the future new types of CO_2 machines will be evolved making use of other physical properties of this gas.

Temperature Distribution in Diesel Engine Liners

In a paper by H. F. G. Letson, before the Institute of Mechanical Engineers, England, data on a series of tests on the temperatures in a Diesel engine were given, together with the author's conclusions on the effect of the wall condition and thickness.

It was found that the load is one of the important factors governing the temperature of the cylinder liner, but owing to the faulty and uncertain action of the governor, it was impossible to obtain exactly any predetermined brake horsepower. The cooling water also governs the liner temperature, but the inlet temperature could not be governed and varied during the tests. The outlet temperature was regulated by varying the amount of water passing through the engine.

After a series of liner temperature tests had been run, the liner was cleaned of all scale. The rise in temperature of the liner with the rise in temperature of the cooling water was more rapid in the case of the clean liner. The temperatures dropped quite rapidly from top to a position about halfway down the stroke, and from there downward the fall was very gradual. The distribution of temperature down the liner changed with the load and the cooling-water temperatures.

It was found that at any one load the gradients did not change appreciably over the range of cooling-water temperatures used. This average gradient is proportional to the difference in temperature between the gases in the cylinder and the combustion face of the liner. Assuming that this difference in temperature between the gases and the inner surface of the liner is roughly about 1,000 deg. C., a considerable variation in the liner temperature would cause only a small variation in the amount of heat passing through it, and consequently only a correspondingly small change in the gradient.

The circumferential and axial stresses are clearly greatest at the surface. As the stresses are directly proportional to the temperature difference between the surfaces, the amount of the stress at any point for any surface-temperature difference may be easily determined from the curves given in the paper, which can be applied to any of the unsupported water-jacketed portions of the engine liner.

Sources of Alternating-Current Auxiliary Power*

Systems Available for Supplying Power to Auxiliary Drives—Advantages and Disadvantages—Diagrams of Four Different Proposed Systems Are Given and Discussed

By G. G. BELL
Manager Power Development, West Penn Power Company, Pittsburgh, Pa.

THE following plan for supplying power to alternating-current auxiliaries and safeguarding their operation have been developed:

1. By taking power from the main bus and by the installation of large-sized motors, so that the torque of the motor is sufficient under all conditions to maintain the pump running in step with the main unit.

2. By using an alternating-current house generator to carry at least all of the essential electric-driven auxiliary load.

3. By installing a house generator which carries a small percentage of the auxiliary load at all times, or no load except when a reduction in speed of a certain amount occurs in the main unit, at which time the governor valve opens and the auxiliary load is picked up by the house generator and carried at a speed somewhat lower than normal.

4. By driving from the shaft of the main turbine an auxiliary generator of sufficient size to carry the auxiliaries.

The last two schemes have resulted from the introduction of steam extraction for feed-water heating. There is little difference in the initial cost or losses of the equipment in any of the plans outlined, as a house generator probably could be built to run at 3,600 r.p.m. as cheaply as an auxiliary generator to run at 1,800 or possibly 1,200 r.p.m. This difference in cost of the generator because of the speed, would offset the cost of the house turbine. On the latter the unit cost is about the same as that of the main unit and condenser.

A house generator to carry load would have a lower steam rate than the spinning house generator. Considering the fact, however, that this turbine is operated only a fraction of one per cent of the time, economy is unimportant.

Taking power from the main bus, as in plan No. 1, is the most efficient if the feed water is heated to the proper temperature, but does not provide a reliable source of stand-by power.

The second plan using the house turbine is more reliable than the first, but less efficient.

The combination in plan three is nearly as efficient as the first and is nearly as reliable as the second.

The fourth scheme is as efficient as the first and has a separate source of power for the electrically driven auxiliaries which is reliable so long as the main unit runs at normal speed.

Both the second and third plans have the advantage of providing a unit that can be started up quickly in case of emergency, and power for starting up auxiliaries can be supplied in case of failure of external transmission lines.

In the electrical layout of stations, especially in those in which it is necessary to step up the voltage before distribution, the tendency is to simplify as far as possible, and in some cases to eliminate entirely, switching at generator voltage. This considers the transformer and generator as a unit, the units paralleled on the high side.

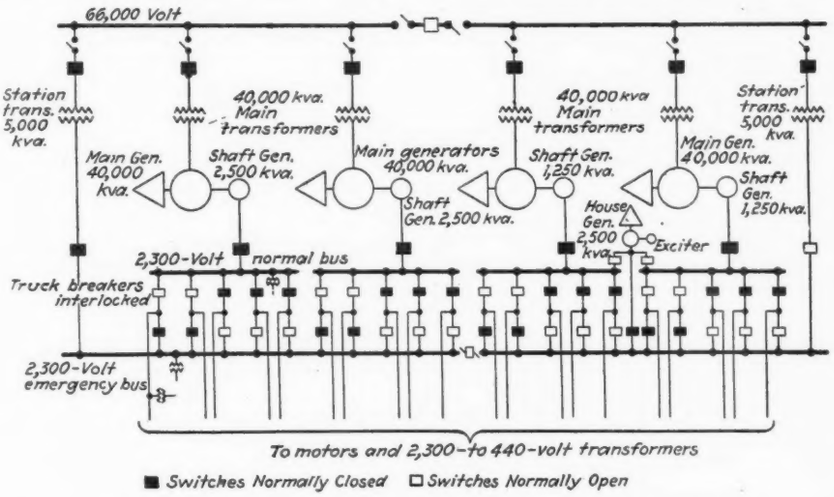


Fig. 1—Proposed arrangement of power supply to auxiliaries

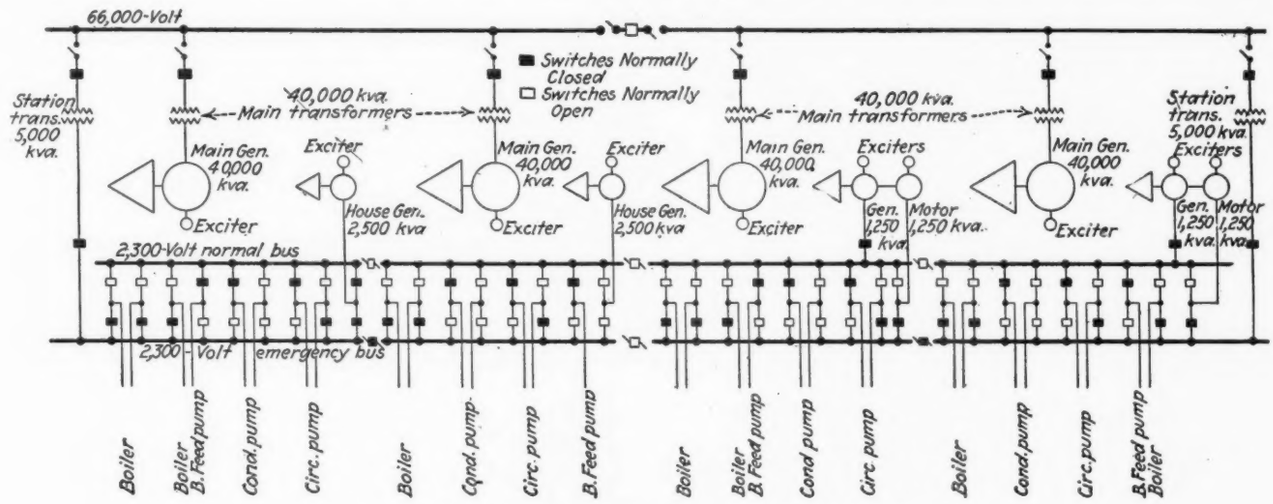


Fig. 2—Two plans of utilizing spinning house generator

*Excerpts from a paper read before the Chicago Section of the American Society of Mechanical Engineers, Jan. 15, 1925.

Trouble probably would occur from circulating current, in case the generators were paralleled at the auxiliary bus voltage, if the sectionalizing switches of the high-tension bus should open. In view of these facts the tendency in the modern station depending upon alternating - current auxiliary power, is to equip the auxiliaries of each generator with its own regular and relay supply for the auxiliaries, and in some cases to provide automatic throw-over switches that will transfer the auxiliary load in case of failure of the regular or relay supply.

Methods of Supplying Auxiliary Power

Fig. 1 is a wiring diagram of a station in which the practice of paralleling on the high side of the transformers has been adopted. The left-hand end of this diagram shows a station that would depend on auxiliary generators for its reliable source of power for driving auxiliaries, and on automatic throw-over devices to transfer the load to the house-generator bus in case of trouble to the main unit. It would be advantageous to use full-voltage starting motors with such a layout. The only disadvantage of this plan is that no small steam-driven unit is provided for starting up the station in case the load is lost, or to pick up the auxiliary load in case the automatic trip operates on the main unit should the other main units be down at the same time.

At the right end of this diagram is shown a layout for the same station, with the exception that one house turbine is provided for each two units; and the switching arrangement is such that in case of loss of voltage on the essential auxiliary bus, the load on that bus is automatically transferred to the house generator. In this arrangement the size of the auxiliary generator is cut in two and only the most essential part of the load is normally carried on the auxiliary generators.

Normally, the house generator is operated in parallel with the auxiliary transformers, and reverse-current relays are provided to disconnect the auxiliary transformer bus from the main unit in case the house generator is discharging current into the main bus in excess of a predetermined amount. This plan has the advantage of providing a reliable source of power for the essential auxiliaries, but normally having them operated from a circuit electrically independent of the main unit.

Using House Generator

In Fig. 2 are shown two plans in which a 2,000-kw. spinning house generator is used to furnish a reliable source of power for the auxiliaries which are normally driven from the house transformers. At the left of this diagram is shown a 2,000-kw. spinning house generator, which can be connected to both buses, the essential auxiliaries being driven off one, and the non-essential auxiliaries off the other, to which the house transformers also are connected. Normally, the power is supplied from the house transformers. The two buses are operated in parallel, the switches of the house generator being so relayed that in case of trouble it remains connected to the bus supplying the essential auxiliaries.

In case there is a reversal of current exceeding a certain amount through the auxiliary transformers, they are disconnected from the auxiliary bus. If the current generated by the house generator exceeds a certain amount, it is disconnected from the auxiliary bus. This arrangement provides a unit for starting up in case of trouble and a source of power for the essential auxiliaries in case of irregularity in supply from the main unit. The main objection to it is that the essential auxiliaries are operated in parallel with the main bus, and although the house transformers have high reactance, there is a possibility of trouble to the auxiliary motors from the lines.

At the right-hand end of Fig. 2 is shown another type of spinning house generator. A 2,000-kw. unit equipped with both a generator and motor, the motor being connected normally to the auxiliary transformer bus and driving the generator to supply the essential auxiliaries. In case of failure of the power supply to the motor, the governor on the spinning house turbine opens, after a drop in speed of approximately 5 per cent, and furnishes power to drive the essential auxiliaries. This generator and motor combination may be made up in several ways:

Motor and Generator Combination

First, two synchronous generators of 1,250-kva. capacity may be connected to the one spinning house turbine — one being normally operated as a motor and the other as a generator. In case it is necessary, both ends can operate as a generator, and this arrangement has the advantage that in case of failure of power to the end operating as a motor, it also will become a generator and furnish current to the non-essential auxiliaries.

Second, a 2,500-kva. duplex driven set, consisting of a generator, induction motor and a spinning house turbine, could be used, as outlined previously, except that in case of failure of current to the induction motor, unless some form of external excitation was provided, it would not act as a generator and drive the non-essential auxiliaries.

Third, it would be possible to develop a synchronous generator having two parallel windings and one field, which would occupy less space and might be obtained at lower cost than the foregoing combinations. It would have the disadvantage, however, of having the windings of the two sections in the same slot.

One of these arrangements should give reliable service, as the essential auxiliaries always would be driven from a source that has only a mechanical conection with the transmission system; and two sources of power are provided, one from the main unit and the other from the spinning house generator.

It would seem as if a spinning house generator, as shown at the left-hand end of Fig. 2, or a combination of half-sized auxiliary generators and spinning house generator, as shown at the right-hand end of Fig. 1, should furnish a reasonably cheap and efficient source of power for the motor-driven auxiliaries.

How One Boiler Plant Improved Operation

In spite of the educational work that has been done along this line, there are still many plants where the boiler-room operation falls far below what is easily possible. It has become the rule for the large stations to employ expert help and give considerable attention to the matter of efficiency, but many small and medium-sized plants are still operated on an unscientific basis, with a resulting large waste of fuel.

It is perhaps to call public attention to this fact and to encourage more attention to fuel economy, that the Bureau of Mines has been investigating specific plants, testing them at the start, making simple changes in operation, and then testing again to discover improvements. Such a test is described by J. F. Barkley, fuel engineer, Bureau of Mines, in a recent investigation report issued by the Bureau. The report bears the serial number 2678, and is dated March, 1925.

The plant described by Mr. Barkley had two 10,000-sq.ft. boilers equipped with multiple-retort underfeed stokers. A test under regular operating conditions was run on one of the boilers at the summer load. Space does not permit reproducing the results of this test, except to note the significant fact that the CO_2 was 6.6. No other data are needed to indicate the possibility of a large improvement in efficiency.

Finding the Cause of Low CO_2

The next step was to find the cause of this low CO_2. The boiler was taken off the line and examined. Holes in the baffles were found at the joints of the baffles and water legs. Some half-tile had been omitted, which permitted shortcircuiting of the gases.

To the casual observer the boiler setting appeared to be in excellent condition. There were no noticeable cracks in the brickwork. However, the common mistake of a leaky setting was there. There were leaks at the doors and the joints of the boiler and setting. Soot-blower nozzles placed at the ends of the boiler had backed out, leaving holes for air leakage. The main leakage of excess air, however, was through the stoker itself.

These difficulties were remedied. In addition the high bridge wall in the boiler which intercepted some of the radiant heat was trimmed sufficiently along the top with a slanting cut to expose the entire length of the tubes to most of the fire. This did not result in any appreciable loss of mixing action and reduced clinkering by lowering the furnace temperature.

In addition to these few simple changes on the boiler an ordinary U-tube water manometer was placed to show the pressure of air under the stoker. Another was used to show the pressure in the furnace. The firemen were trained in the use of the manometers and in the proper appearance of a fire. A final test was then run under regular operating conditions at the summer load. This showed a CO_2 of 11.45 and an increase of approximately 10 per cent in boiler efficiency.

Plans for Richmond Station, Philadelphia Electric Co.

The plans for the Richmond station of the Philadelphia Electric Co., Philadelphia, Pa., call for buildings to be constructed in three separate units, each unit to house 200,000 kw., making a total plant capacity of 600,000 kw.

There are to be twelve boilers installed this year, each unit being equipped with superheater, economizer and preheater, having the following heating surfaces: Boiler, 15,697 sq.ft.; superheater, 2,822 sq.ft.; economizer 7,515 sq.ft.; preheater, 22,072 sq.ft. In the ultimate installation there will be 72 boilers of the same capacity.

Under the twelve boilers are ten Taylor stokers, each having 15 retorts and 25 tuyeres, and two Westinghouse stokers, also having 15 retorts and 25 tuyeres each.

The present turbine installation consists of two 50,000-kw. single-shaft units.

The boiler units are designed to operate at a maximum rating of 350 per cent and an average or normal rating of 175 per cent.

Chicago Diversion Still Being Fought

Preliminary plans to oppose excessive diversion of lake water by the Chicago Sanitary District were mapped out in Cleveland on April 3, according to press reports, when a Canadian representative and Attorney Generals of several states bordering on the Great Lakes met with Harvey D. Goulder, of Cleveland, general counsel for the Lake Carriers' Association.

At the conclusion of the meeting Mr. Goulder issued the following statement:

"The Lake States and important navigation interests, including those dependent thereon, that have been united in their efforts to obtain relief from the serious damage occasioned by the Chicago diversion, have recognized that the recent decision of the Secretary of War restricting the Chicago diversion is a decision that is, essentially, but a temporary and partial relief begotten of the exigency of the general situation.

"Attorney Generals and other representatives of the interests involved are determined that they shall energetically continue their efforts to secure the maximum relief from the Chicago diversion. With this object, a meeting of representatives has been held in Cleveland for informal discussion and for the formulation of general plans, through which, in the early future, there will be a more drastic cutting down of such diversion as the War Department has temporarily permitted."

Coal Dock Operators Get Adverse Ruling

Ten coal dock operators organized into the unincorporated Northwestern Coal Dock Operator's Association, with the association, are required in an order issued by the Federal Trade Commission to cease and desist from entering into any agreement or combination to restrain or suppress competition in the sale of bituminous and anthracite coal at wholesale or retail. The respondent companies are: Pittsburgh Coal Co. of Wisconsin, Minneapolis; Northwestern Fuel Co., St. Paul; C. Reiss Coal Co., Sheboygan; Clarkson Coal & Dock Co., St. Paul; M. A. Hanna Coal & Dock Co., Cleveland; Carnegie Dock & Fuel Co., Pittsburgh; Berwind Fuel Co., Chicago; Northern Coal & Dock Co., St. Paul; Great Lakes Coal & Dock Co., Minneapolis; Pittsburgh & Ashland Coal & Dock Co., Cleveland.

Among other things that the association is ordered not to do is to furnish statistics to its secretary. The association may not gather data on costs of operation or on shipments that have been made. This is a new interpretation of permissible statistical activities of a trade association. The Commission's ruling that statements may not be made of number of cars to be shipped in the future or the prices charged on shipments actually made is in line with court rulings.

It is feared that the effect of the order will be to limit still further the activities of trade associations in collecting and using statistics. It is important to note, however, that it is the use to which the Commission alleges the Dock Association figures were put, rather than their assembling, which is attacked. The inference is that, properly used, there would be no objection to the gathering of, at least, certain figures.

G. E. Co's. Business Compared for Three Months of 1924 and 1925

AN INDICATION of the present economic condition in the power and electrical field is indicated by the statement of Gerard Swope, president of the General Electrical Co., in his statement that orders for the first three months of 1925 were $83,846, 236 as compared to $73,487,903 for the same period in 1924, and show an increase of 14 per cent.

International Congress of Heating and Ventilating

There will be held in Paris in June an International Congress of Heating & Ventilating Engineers, according to information obtained from its technical secretary, Mr. Beaurrienne. Mr. Rozack, who is professor at the Ecole Centrale des Arts et Manufacturers and the French School of Engineering, is to be president of the Congress. An invitation has been extended to American engineers who may be visiting abroad during the summer, to attend.

Ontario To Build Plant on Ottawa River

Premier Ferguson has announced to the Ontario Legislature that the government had authorized the development of power by the Provincial Hydro-Electric Power Commission at Rocher Fondu on the Ottawa River near Arnprior. The development, with storage, will provide 66,000 hp., and with the present minimum flow will produce 45,000 hp. It is estimated that the work will cost over $5,000,000.

The commission proposes to construct the power plant on an island on the Quebec side of the river. As the stream is the interprovincial boundary at this point, the arrangements are subject to negotiations with the Province of Quebec.

Two Bids Certain for Muscle Shoals Power

There will be at least two bidders for the temporary use of Muscle Shoals power. It has been known for some time that the associated power companies in the Southeast would submit a bid. The Secretary of War was asked on April 3, by the Union Carbide Co. for permission to bid for the temporary lease.

Owing to the illness of the Secretary of War, there has been some delay in advertising for bids for the temporary use of the power. The announcement by the Union Carbide Co. that it desires to submit a bid was unexpected. That company is said to contemplate using practically all the power that will be available for the manufacture of uria in Nitrate Plant No. 2.

Steps are being taken looking to the construction of a transmission line connecting the end of the dam with the switchboard at the steam plant two miles away. The cost is $500,000.

In its contract the War Department will reserve the right to make such tests as it desires before beginning to deliver power from the dam. In addition some time likely will be needed for the adjustments of the generators and of the machinery.

Meetings Scheduled for Oil and Gas Power Week April 20 to 25

These Meetings are to be Held Under the Auspices of the Various National Technical Societies

ALABAMA

Auburn—April 20. Engineering Hall, Alabama Polytechnic Institute, 7 p.m.

Birmingham—April 24. Lincoln Life Building, 8 p.m. "High Pressure Steam Lubrication," by W. F. Stack; "Production and Utilization of Gas in the Birmingham District," by A. C. Overton; "Oil-Burning Furnaces in Residences," by C. P. Lichty.

CALIFORNIA

Los Angeles—April 23. Dinner Meeting at the Mary Louise Tea Room. "Conservation in Oil Fields," by R. R. Templeton. Union Oil Co., "Boilers Efficiently Using Oil and Gas Fuels," by Guy L. Warden; "Refinery Wastes"; "Oil Losses in the Earth."

April 23. Luncheon, Broadway Department Store restaurant. "Conservation of Oil and Gas."

During the week, plant visits to southern California oil fields, Southern California Edison Co. and Los Angeles Gas & Electric Co.

Pasadena—April 22. California Institute of Technology, 7:30 p.m. "Description of Research Laboratory of General Petroleum Co."

San Francisco—April 24. Merlin Hall, Druids Temple, 8 p.m.

April 23. Engineers Club, 8 p.m.

COLORADO

Denver—April 21, Luncheon at the Alpine Rose Restaurant. Subjects and speakers to be announced.

April 21. 1751 Champa Street at 8 p.m. "Influence of Human Element on Operation of Oil Engine Units"; "The Increasing Interest in Diesel Engines"; "Diesel Engines in Plants Requiring Steam."

Fort Collins—April 20. Mechanical Engineering Building of the State Agricultural College, 7 p.m.

CONNECTICUT

Bridgeport—April 20. Luncheon in Breakfast Room, Stratfield Hotel. "Ways and Means in Conserving, in the Use of Illuminating Gas," by F. S. Hawley; "Methods Employed to Increase the Mileage Obtained from Gasoline," by D. G. Roos. Regular Chamber of Commerce Luncheon with A.C.S. (New Haven Section), A.S.M.E., N.A.S.E. No. 4. and Engineers Club of Bridgeport furnishing technical program. Open meeting.

April 23. Stratfield Hotel, 8 p.m. "Gas and Oil Situation in the Country at Present and the Need of Conservation," by Dr. Alan M. Bateman, Yale University; "Diesel Engines," by Edward J. Shennan.

New Haven — April 25. Gamble Desmond Building, 8 p.m. Lecture on Oil and Gas Power. Plant visit to Winchester Repeating Arms Co.

DISTRICT OF COLUMBIA

Washington, D. C.—April 23. Cosmos Club at 8 p.m. "The Diesel Engine in Submarines," by E. C. Magdeburger, Navy Department. A.S.M.E., A.I.C.E., A.S.N.E., A.C.S., Washington Society of Engineers, Bureau of Mines, Bureau of Standards, Geological Survey,

FLORIDA

Jacksonville—April 21. Meeting under auspices of Jacksonville Engineers Club.

GEORGIA

Atlanta — April 24. Chamber of Commerce Building, 8 p.m. "The Use of Oil Fired Furnaces in Residences," by A. M. Schoen.

April 24. Georgia School of Technology, 11 a.m. "Crude Oil Refinery," by George Griffin; "Late Development of Solid Injection Oil Engines," by J. Nesbit Marye.

ILLINOIS

Chicago — April 23. Armour Institute of Technology, 11:30 a.m. "Field and Laboratory Experiments with Stationary Gas Engines," by Professor D. Roesch; tests on the Hvid Engine are going on in the Gas Laboratory.

April 22. Nineteen West Adams Street, 8 p.m. "Oil, Its Benefits as Fuel," by R. A. King; "Oil Lubrication," by J. W. Harkins; "Oil Engines," by Alfred Johnson. Meeting under auspices of N.A.S.E. Nos. 1 and 2.

April 25. Capital Building, 8 p.m. "Oil, Its Benefits as Fuel," by R. A. King; "Oil Lubrication," by J. W. Harkins; "Oil Engines," by Alfred Johnson.

April 17. Rooms of Western Society of Engineers, 8 p.m. "Diesel Engine Development," by Philip L. Scott, Super Diesel Tractor Corp.

Urbana—April 22. Laboratory University of Illinois.

Moline—April 21. Skinner Building, 8 p.m. "Automobile Engines"; "Diesel Engines"; "Oil Burning,"

INDIANA

West Lafayette — April 20. Purdue Union Building, 3 p.m. "Internal Combustion Engine in Industry," by Prof. A. C. Staley.

IOWA

Cedar Rapids—April 20. Sokol Hall, 517 So. Third St., 8 p.m. "The Increasing Interest in Diesel Engines," by Ray C. Burrus; "Diesel Engines in Plants Requiring Steam," by L. H. Morrison.

KANSAS

Manhattan—April 16. Kansas State Agricultural College, 4 p.m. "Gasoline Refining," by J. M. McBurney; "Testing of Lubricating Oils to meet the Specifications required by the State," by Paul Speer.

Lawrence—April 17. University of Kansas, 10 a.m. and 2 p.m. Speakers: John Lyle Harrington, past president, A.S.M.E.; W. M. Wood, Kansas City Engineers Club; E. O. Bennett, Bureau of Mines; F. S. Dewey, A.I.E.E.; F. E. Jones, A.S.M.E.; C. A. Swiggett; Dr. H. Cross, A.C.S.; R. S. Knappen, Kansas Geological Survey.

LOUISIANA

Baton Rouge — April 22. Physics Lecture Room, Louisiana State University Campus, 7:30 p.m. "A Discussion of the Oil Resources of Louisiana," by Dr. Henry V. Howe, professor of Geology and Mineralogy.

New Orleans—April 25. B. K. A. Hall, 8 p.m. "The Increasing Interest in Diesel Engines," by Ray C. Burrus.

MAINE

Orono—April 22. Lord Hall, University of Maine. "Influence of Human Element on Operation of Oil Engines,"

MARYLAND

Baltimore — April 22. Luncheon at Engineers Club. "Oil and Gas Engines," by Leon Wygodsky.

April 17. Bethlehem Steel Company's Offices, Sparrows Point, Maryland, 2 p.m. to 9:30 p.m. Inspection of gas engine and other power plants of Bethlehem Steel Company from 2 to 5:30 p.m. Dinner 6:30 to 7:30 p.m. Technical session 7:30 to 9:30 p.m. "Heat Available in Coke Oven, Blast Furnace and Open Hearth Gas," by Mr. Coulter; "Gas Engine Practice in the Steel Mill, for Blowing and Electric," by Mr. Raymond"; Power Generation from Gas Fired Boilers," by Mr. Schnure.

April 23. Room 109, Mechanical Engineering Building, 4:15 p.m. "The Chemistry of Engine Fuels," by Dr. J. W. Huff, Johns Hopkins University.

MASSACHUSETTS

Lowell—April 21. Lowell Textile School, 3 p.m. John A. Stevens, consulting enginer, speaker.

East Cambridge—April 23. Plant of Worthington Pump & Machinery Corporation, 3 p.m. "Diesel Engines," by James L. Yates.

Worcester — April 22. Hour and place to be announced. Lt. Com. W. H. Pashley, U.S.N., speaker.

MICHIGAN

Detroit—April 16. I. O. O. F. Hall, Grand River and Avery Avenues, 8 p.m. "Influence of Human Element on Operation of Oil Engine Units," by A. B. Newell; "Increasing Interest in Diesel Engines," by Ray C. Burrus; "Diesel Engines in Plants Requiring Steam," by L. H. Morrison, editorial staff of *Power*.

Flint—April 23. Municipal Market Building. Subject and hour to be announced. Meeting of N.A.S.E. No. 23.

Hastings — April 25. City Water Works. Subject and hour to be announced. Meeting of N.A.S.E. No. 6.

East Lansing—April 23. Old's Engineering Hall, Michigan Agricultural College, 10 a.m. "Review of Oil and Gas Power Material appearing in Engineering Periodicals."

Grand Rapids — April 20. Meeting at 112¾ Pearl St. "The Motor Fuel Situation," by A. J. Kraemer, Asst. Chemist, U. S. Bureau of Mines, Washington, D. C.

MINNESOTA

Minneapolis—April 20. Dinner meeting at the Y.M.C.A. "Dilution, Carbon, Sludge in Engine Crankcases for automobile Engines," by Victor C. Parker.

April 27. Dinner meeting at Y.M.C.A. "Consumption of Fuel Oil," by E. J. Larkin, M. E.

April 25. Auditorium, Main Engineering Building, University of Minnesota, 10:30 a.m. "The Story of Oil," by L. A. Baudoin, Sinclair Oil Co.

MISSOURI

St. Louis—April 21. St. Louis Electrical Board of Trade Meeting at Chamber of Commerce, 12:30 p.m. "Lubrication, with special Reference to the Automotive Field," by Col. T. A. Peck, Pierce Petroleum Corp.

April 22. Engineers Club, 3817 Olive St., 8 p.m. "Is a Gasoline Shortage Probable?" by H. A. Wheeler, geologist and mining engineer.

April 24. Dinner meeting at American Annex Hotel. "The Diesel Engine as a Prime Mover for Moderate Size Power Plants," by Col. John A. Laird, vice-president, Morrison & McCall, and secretary, St. Louis Electrical Board of Trade. "Artificial Gas Situation in the St. Louis Territory," by W. D. Thompson, Laclede Gas Light Co. Additional short talks. Meeting of A.S.M.E. with members of participating societies invited.

Kansas City — April 24. Complimentary dinner by manufacturers of Diesel engines, at the University Club. "The Diesel Engine in Industry," by S. A. Hadley, McIntosh - Seymour Corp.; "The Diesel Engine as a Drive for Pumps and Compressors," by F. I. Kemp, Worthington Pump & Machinery Corp.; "Power Plants on the Northern Division of the Prairie Pipe Line Company," by Jess English; The Prairie Pipe Line Co.; "Diesel Engine Specifications," by H. P. Morris, Fulton Iron Works"; Diesel Engines on Pipe Lines," by Fred Thelineus, The Prairie Pipe Line Co. Meeting of Kansas City Section, A.S.M.E.

NEBRASKA

Lincoln—April 25. Dinner at the Grand Hotel. Meeting at 8 p.m., University of Nebraska. "Chemistry of Gas and Oil Engine Fuels," by Prof. C. J. Frankforter, of the Chemistry Department; "Lubrication," by J. Duguid, Galena-Signal Oil Co.

NEW JERSEY

Hoboken — April 24. Meeting at Palace Garden, 412 Washington St. "The Increasing Interest in Diesel Engines," by Ray C. Burrus.

Plainfield — April 22. Auditorium, Y.M.C.A., 8 p.m.

Plant excursion to International Motors Co., West Front St. near Clinton Ave. at 2:30 p.m., April 23.

April 22. In William Hall Walker Gymnasium, Stevens Institute of Tech-

nology, 7 p.m. "Oil and Gas Power," by R. G. Melrose, Ocean Accident & Guarantee Corp., New York. A.S.M.E. Student Branches of Stevens Institute of Technology, New York University, Columbia, College of City of N. Y., Cooper Union, Brooklyn Polytechnic Institute, Newark Tech., Pratt Institute, Rutgers College, participating.

NEW YORK

Buffalo—April 25. 796 Ellicott St. at 8:30. "Diesel Engines in Plants Requiring Steam," by L. H. Morrison.

New York—April 22. Engineering Societies Building, 29 West 39th St., 8:15 p.m. "Oil Engine Locomotives," by Edwin B. Katte, New York Central R.R.; L. G. Coleman, Ingersoll-Rand Co., Elmer A. Sperry, Sperry Gyroscope Co. Meeting of A.S.M.E., Metropolitan Section, preceded by dinner at Building Trades Club at 6:30 p.m. April 25. Meeting at Terrace Garden, 145 E. 58th St., hour to be announced. "Diesel Engines." R. M. Tucker, Fulton Iron Works Co., on "The Four-Cycle Engine," and F. J. Cunneen, Nordberg Manufacturing Co. on the "Two Cycle Engine."

Niagara Falls—April 24. Meeting at Eagles' Hall, Main St. Subject and hour to be announced.

Brooklyn—April 23. Chemistry Building, Pratt Institute, 10 a.m. "Diesel and Gas Engines."

Schenectady—April 21. Edison Club Hall, 8 p.m. "The Diesel Engine as applied to Railroad Locomotives," by F. W. O'Neil, Ingersoll-Rand Co.; "The Electrical Features of Railroad Locomotives driven by Diesel Engines," by W. B. Potter, General Electric Co.; "The Mechanical Features of Railroad Locomotives driven by Diesel Engines," by G. B. Ashworth, American Locomotive Co.

Tonawanda—April 20. Orales Hall, 8:30 p.m. "General Outline of Gas Blowing Engine Practice," by C. G. Sprado.

NORTH CAROLINA

Raleigh—April 21. North Carolina State College, 7 p.m. "Oil," by Dr. E. A. Randolph; "Gas," by Dr. W. J. Dana, Professor of Experimental Engineering.

NORTH DAKOTA

Grand Forks—April 20. University of North Dakota, 7:15 p.m. "Influence of Human Element on Operation of Oil Engine Units," by A. B. Newell.

OHIO

Akron—April 25. Harvest Room, Portage Hotel, 7:30 p.m. "Diesel Engines," by R. C. Demary; "Increased Use of Fuel Oil," by William Robberts.

Cleveland—April 20. Hollenden Hotel, 7:30 p.m. "Automotive Connecting Rods."

April 23. Physics Building, Case Campus, 10 a.m. "Industrial Uses of Gas," by W. E. Stark, Bryant Heater Co. 8 p.m., Assembly Room, Physics Building, Case Campus. "Diesel Engines," by L. H. Morrison, editorial staff, *Power*, New York.

Columbus—April 24. Ohio State University Auditorium, 4 p.m. "Oil Engine Locomotives," by L. H. Morrison, editorial staff, *Power*,

Meeting at Chamber of Commerce, East Broad St., 8 p.m., "Recent Developments in Large American Diesel Engines," by L. H. Morrison; "Some Observations on the Combustion Processes in Solid-Injection Oil Engines," by H. F. Shepherd, Foos Gas Engine Co.; "Manufacture of the Important Parts of Solid-Injection Oil Engines," by J. E. Dykstra, Foos Gas Engine Co.

Dayton—April 20-24, Exhibit of domestic gas supply units, Smith Gas Engineering Co., Moraine City, Dayton.

April 25. Excursion to Power Plant Laboratory, 9 a.m., McCook Field. Aircraft Engine Development, *or* Excursion to Chemical Laboratory, McCook Field, Methods of Testing Fuels and Oils for Aviation Purposes. 10:30 a.m., in the McCook Field Auditorium. "Diesel Engines and Their Possibilities for Aircraft and Automotive Use."

Lima—April 23. At 219½ South Main St., 7 p.m., "Oil Engines," by A. Gillett, Buckeye Machine Co. Plant visits in afternoon to White Mountain Creamery Co., Garford Motor Works, and Buckeye Machine Co. Reception from 5 to 7 p.m.

Ada—April 22. Hill Building 7 p.m. "One Way to Conserve Our Waning Petroleum Supply," by C. Nieswander, Buckeye Machine Co.

Toledo—April 23. Visit to plant of Standard Oil Company, East Bay Shore, 2:30 p.m. Dinner at Toledo Yacht Club, followed by technical meeting. "Recent Progress in Refining Petroleum," by Dr. W. A. Gruse, Mellon Institute of Industrial Research, Pittsburgh, Pa.

Youngstown—April 23. Dinner meeting at Tod House. Technical meeting, 8 p.m. "Oil Engines," by W. L. Russell, Worthington Pump & Machinery Corp.

OKLAHOMA

Tulsa—April 24. In the morning a meeting of the participating societies; in the afternoon a general meeting on the subject of Petroleum Conservation; in the evening a banquet at the Mayo Hotel.

Stillwater—April 23. In College Auditorium, Oklahoma Agri. and Mech. College, 11 a.m. Subject to be announced.

OREGON

Corvallis—April 21. Engineering Laboratory, Oregon State Agricultural College, at 7:15 p.m. "Effect of Temperature and Pressure on Oil Vapors," by Prof. Floyd E. Rowland.

April 23, in Engineering Laboratory, Oregon State Agricultural College, 7:15 p.m. "Some Practical Factors in Gas and Air Compression, Emphasizing Distribution at High Pressures," by Prof. Samuel H. Graf.

Portland—April 25. Dinner Meeting at Chamber of Commerce. "The Use of Oil Fuel in the Logging Industry," by Allen Chisholm, Smith & Watson Iron Works; "Modern Two-Cycle Solid-Injection Diesel Engines," by Charles Eichbaum, Worthington Pump & Machinery Corp.

PENNSYLVANIA

Bethlehem—April 23. Lehigh University, 8 p.m. Informal Reception. General discussion of Oil and Gas, by Dr. Benjamin L. Miller.

Easton—April 23. Pardee Hall, Lafayette College, 2 p.m. "Report of Tests on a Hvid Oil Engine," by F. E. Armstrong and E. W. Miller.

Erie—April 22. Smoker at Chamber of Commerce, 8 p.m. "Diesel Engines," by L. H. Morrison, Editorial Staff, *Power*, New York.

Philadelphia—April 14. Kuglers Restaurant, 34 So. 15th St., 8 p.m. "Lubrication and Distillation of Automotive Fuels," by John D. Gill. Atlantic Refining Co. Preceded by informal reception at 6 p.m.

April 16. University of Pennsylvania, 8 p.m. "Research Problems Presented by the Petroleum Situation," by Dr. J. B. Hill, Atlantic Refining Co. "The Development of the Petroleum Situation," by Albert G. Peterkin, Atlantic Refining Co.

April 21. Informal Dinner at Engineers Club, meeting at Engineers Club, 8 p.m. "The Cross Cracking Process and the Continuous Pipe Still." Walter Samans, Atlantic Refining Co. John Primrose, Power Specialty Co. L. H. Harrison, M. W. Kellogg Co.

April 22. Textile Hall, Kensington Ave. and Cumberland St., 8 p.m. "Influence of Human Element on Operation of Oil Engine Units," by A. B. Newell.

April 24. 814 No. Broad St., 8 p.m. "Diesel Engines in Plants Requiring Steam," by L. H. Morrison. Meeting of N.A.S.E. Associations in Philadelphia, including Nos. 1, 9, 12 and 20.

Pittsburgh—April 22. William Penn Hotel, 8 p.m. Speakers to be announced.

April 20. Dinner Meeting, at William Penn Hotel, of Local Executive Committees of participating societies. Speaker: Dr. W. F. Durand, President, A.S.M.E.

State College—April 17. Banquet at State College Hotel. Guests of honor: Dr. W. F. Durand, president, A.S.M.E., Lt. Com. E. E. Wilson, U.S.N., and officers and members of the A.S.M.E. Central Pennsylvania Section. Meeting under auspices of Pennsylvania State College, A.S.M.E. Student Branch.

April 18. Bucknell University, Lewisburg, Pa., 1:30 p.m. "Power Plants for Aircraft," by Lt. Com. E. E. Wilson, U.S.N., Navy Department; "The Engineering Point of View as Applied to the Work of the Chief Executive," by Wallace Clark, Industrial Engineer.

April 22. State College, 7:30 p.m. "The Story of Gasoline," by Dean G. L. Wendt, Pa. State College.

PORTO RICO

Mayaguez—April 21. University of Porto Rico, 4:30 p.m. Informal Reception for visiting engineers. "Fuel Oil and Its Use in Porto Rico," by M. Vasquez; "Anti-Knock Compounds," by C. Chiesa.

TENNESSEE

Knoxville—April 21. Civic Building, 6:30 p.m. "The Diesel Engine," by Dean C. E. Ferris, University of Tennessee; "The Flow of Gases," by E. V. Gmeiner; "Comparison of Oil and Coal as Fuel in Tennessee," by W. R. Woolrich; "Oil Burning Furnaces for Residence Heating," by Horace Macon.

TEXAS

Dallas—April 20. Meeting at 1808½ Main St., 8 p.m. "Use of Natural Gas for Power and Heating, and Use of Gas Engines in Time of Peak Natural Gas Supply," by W. D. Carpenter, Lone Star Gas Co.

April 21. Visit to Standard Tilton Milling Co., 8 p.m. April 22. Visit to Lone Star Relay Gas Station, 8 p.m. April 23. Visit to Trinity Portland Cement Co., 8 p.m. April 24. Visit to Dallas Power and Light Co., 8 p.m.

El Paso—April 21. El Paso Ice and Refrigerating Co., 8:30 p.m. "Influence of Human Element on Operation of Oil Engine Units," by A. B. Newell; "The Increasing Interest in Diesel Engines," by Ray C. Burrus; "Diesel Engines in Plants Requiring Steam," by L. H. Morrison.

Houston—April 22. University Club, 8 p.m. "Thermodynamics of Oil Engines," by Prof. Carnes, of A. & M. College. Fifteen-minute papers by representatives of engine companies and by operators of steam and Diesel plants.

Austin—April 20. University of Texas. "The Tipps Semi-Diesel Engine," by F. A. Smith, Tipps Engine Works. Meeting of A.S.M.E. Student Branch, University of Texas, with A.C.S. Local Section invited. April 22. "The Chemistry of Oil Engine Fuels,"

UTAH

Salt Lake City—April 21. University of Utah, 11:30 a.m. Modern Methods of Refining and Using Oils."

VERMONT

Burlington—April 25. University of Vermont. "Possibilities of Gas and Oil as to Heat and Power."

VIRGINIA

Blacksburg—April 24. Smoker in Reception Hall, Y.M.C.A., 7:45 p.m. Col. J. S. A. Johnson, Professor of Applied Mechanics and Experimental Engineering, Virginia Polytechnic Institute.

Richmond—April 24. Commonwealth Club, 10 a.m. "Fuel Conservation" and "Highway Design," and other papers. 12:30 p.m., luncheon at Hotel Jefferson. 2:30 p.m., meeting at Commonwealth Club. "Fuel Oil and Its Adaptability to Power Plants"; "Oil Engines and their Usefulness in Industry." 4:30 p.m., meeting at Richmond Engineers Club. "Gas as an Industrial Fuel." 6:30 p.m., dinner at the Commonwealth Club. 8 p.m., "The Electrical Industry and Its Dependence on Fuels."

WISCONSIN

Eau Claire—April 21. Knights of Pythias Hall, 8 p.m. "Chemistry of Gas and Oil Engine Fuels," by K. H. Stubenvoll; "Influence of Human Element on Operation of Oil Engines," by A. B. Newell.

Manitowoc—April 23. New Opera House Hall. "Influence of Human Element on Operation of Oil Engine Units," by A. B. Newell.

Milwaukee—April 28. N.A.S.E. Hall, 11th and Walnut St., 8 p.m. "Lubricating Oils."

Madison—April 23. University of Wisconsin, 7:30 p.m. "Diesel Engines," by B. V. E. Nordberg, Jr., Exec. Engr., Nordberg Mfg. Co.

Convention of Refractories Program

The American Refractories Institute, whose formation was announced in the March 31 issue, page 514, will hold its first regular meeting on April 14 at the Mellon Institute of Industrial Research, University of Pittsburgh, Pittsburgh, Pa. After a short business session, the following program of addresses is scheduled:

"The Value of Research in Industry," by Dr. E. R. Weidlein, director, Mellon Institute; a practical discussion of "The Use of Refractories Materials," by H. L. Dixon, president, H. L. Dixon Co., Pittsburgh, Pa.; "Refractories Accounting," by A. J. Farber, Haskins & Sells, Pittsburgh, Pa.; a discussion of "Spalling," by M. C. Booze, Mellon Institute; a discussion of "Relation of Structure and Composition of Refractories to Thermal Efficiency in Regenerators," by S. M. Phelps, Mellon Institute; Inspection of laboratories of Mellon Institute; luncheon at University Club, Natalie Place. "The American Refractories Institute," by J. D. Ramsay, president, Elk Fire Brick Company, St. Marys, Pa.

As previously announced, anyone interested in the manufacture or use of refractories is urged to attend this meeting, regardless of his affiliation with the new organization.

Institute for Corrosion Study Suggested

The causes of rust and corrosion, which annually destroy $300,000,000 worth of metals, and the search for means of checking this loss were subjects of discussion by noted scientists at Johns Hopkins University of a section of the American Chemical Society presided over by Robert J. McKay, of the International Nickel Co., on April 8.

Recent investigations indicated that practically all of the great economic waste involved was due to electrochemical action, especially to the effect of air and water in setting up electrical currents, which caused gradual disintegration of metal.

Among the remedies discussed were the use of alloys, the removal of air from water in pipes, and the vaccination of metals by inducing slight films of corrosion of a type which resist further electrochemical action. Specialists on this subject discussed the question of establishing a corrosion institute, possibly in connection with Columbia University.

Two years ago, according to Chairman McKay, the cause of iron rust was not definitely known. Iron might have united directly with oxygen—that is, it might burn up just as wood or coal does, except more slowly; the rust might be the result of colloidal reactions; or it might be the result of electrochemical action. Investigations of the last two years, it was asserted, have definitely determined that electricity generated by the chemical action of water and air, and especially of the two in combination, was the chief cause. It was found that air had very little effect without water, and that water had very little effect unless it was mixed with air.

Dr. Colin G. Fink, professor of electrochemistry at Columbia University, described a process of making corrosion reverse itself—forcing rust, tarnish and other disintegrative products back into their original metallic state.

This paper gained an interest because the process described was applied to the recreation of small art objects, coins, jewelry and other antiquities of Egypt, Greece, Rome and Etruria, which had degenerated into mere lumps of corrosion.

Dr. W. R. Whitney, to whom tributes were paid as the founder of the electrochemical theory of corrosion, described the ravages of corrosion in steam turbines, in which the devastation of the metal was proportionate to temperature and to pressure.

Coffin Awards Won by Forty-three

Forty-three General Electric Co. employees have received Charles A. Coffin Foundation awards for having made most signal contributions toward the increase of the company's efficiency or progress in the electrical art during 1924. Twelve of the prizes were won by shop men, five by foremen, fifteen by engineers, and seven by commercial men. Four special awards were made for the presentation of papers at company meetings. With each certificate of award there is a prize of $250.

Midwest Power Show's List of Exhibitors Grows

The Midwest Power Show which is to be held in Milwaukee May 18-21, or during the week that the American Society of Mechanical Engineers, the Wisconsin Association of the National Association of Stationary engineers, and the American Society of Refrigerating Engineers are holding their meetings, is on the highroad to success. Up to March 15th there had been 130 different concerns that had reserved from one to six sections for exhibition purposes.

The show is a non-profit undertaking and is intended as a benefit to the visiting engineers as well as to the engineers of the Western States. A real cordial Western welcome is the object of the engineers in charge.

Conowingo Project Backed by Stockholders

The stockholders of the Philadelphia Electric Co. on April 8 approved the $52,000,000 Conowingo (Md.) hydroelectrical project, accepted other recommendations of the board of directors and re-elected the old officers.

Nothing occurred to reflect the recent battle of Thomas D. Mitten, head of the Philadelphia Rapid Transit Co., to obtain enough proxies to control the electric corporation. The transit company, which uses 20 per cent of the electric company's power, objects to the Conowingo project as financially unsound. Mitten offered to raise the electric company's dividends from 8 to 10 per cent if the stockholders would give him sufficient proxies to control. These failed to materialize and Mitten on April 5th announced the abandonment of his contest.

Merger of Niagara Power Companies Rumored

It is rumored, but not confirmed, that negotiations for a merger of the Buffalo General Electric, Niagara Falls Power, and Niagara, Lockport & Ontario Power Companies are in progress. These three companies have their headquarters in Buffalo.

Buenos Aires Company Plans Expansion

The Compania Hispano Americano de Electricidad, which provides electric light and power to the City of Buenos Aires, has petitioned for a concession to build a new power house with a capacity of 142,500 kw. in the vicinity of the new port. Commercial Attaché Edward F. Feely, Buenos Aires, Argentina, states in *Commerce Reports.*

Course for Plant Operators To Be Held at Purdue

The Engineering Extension Service of Purdue University under the direction of the School of Mechanical Engineering, will hold on April 23-25, a "Laboratory Short Course for Power Plant Operators."

The course will be along practical lines covering problems of interest to practical men as follows: "Coal and Ash Analysis"; "Flue Gas Analysis"; "Calibration of Pressure and Vacuum Gages"; "Steam Calorimetry"; "Feed-Water Analysis and Treatment"; "Steam and Gas Engine Indicators and Indicating"; "Steam Engine Valve Setting"; "Steam Engine and Turbine Testing"; "Lubricating Oils."

The industries planning to send one or more of their operating engineers to this Laboratory Short Course are requested to notify the University in advance in order that a detailed program can be arranged. Advance enrollment should be made to Prof. L. V. Ludy, Purdue University, LaFayette, Ind., at once.

The annual report of the Manchester Steam Users Association, dated March 3 of this year, says that since the publication of its last report the association has recorded the occurrence, outside its ranks, of 34 explosions in the United Kingdom. These resulted in the killing of nine persons and injury to 29 others. Nine of these explosions, by which two people were killed and 14 others injured, may be termed boiler explosions proper, while the remaining 25, killing seven persons and injuring 15 others, may be termed miscellaneous explosions, that is, those arising from steam pipes, stops valves, kiers, drying cylinders, bakers' ovens, etc.

Personal Mention

Fred J. Postel, announces that he has disposed of the consulting engineering business of Fred J. Postel & Co. to George A. Muir and Irving E. Brooks, who will continue the business at their present address, 163 W. Washington St., Chicago, Ill., under the name of Muir & Brooks.

Johannes Ruths, D.Sc. has been awarded the Royal Institute of Scientific Research of Sweden's gold medal, for his notable invention of the steam accumulator which equalizes intermittent load on boilers in factories and power plants. This acculator stores steam in hot water under pressure.

Society Affairs

The Erie Section of the A.I.E.E. will have "Automatic Substations," as the subject of its April 21 meeting.

The Seattle Section of the A.I.E.E. will have for its April 15 meeting, "Economies of Transmission Design," by E. A. Loew.

The Cincinnati Section of the A.S.M.E. will hold its April 23 meeting at the Literary Club rooms. The subject will be "The New Miami Fort Station of the Union Gas & Electric Co.," by C. W. DeForest, manager of the company.

The Boston Society of Civil Engineers will have as the subject for its April 15 meeting to be held in Chipman Hall, Tremont Temple, "The Engineering Board of Review of the Sanitary District of Chicago on the Lake Lowering Controversy of Remedial Measures." The speakers will be Harrison P. Eddy and John R. Freeman.

Business Notes

The National Carbon Co., New York City, announces the removal of its emergency brush finishing plant from 237 East 41st St. to 357 West 36th St.

The B. F. Sturtevant Co., Hyde Park, Boston, Mass., announces that Norris R. Sibley, formerly with the Westinghouse Electric & Manufacturing Co., has recently joined its sales organization and is located in the New York office, 52 Vanderbilt Ave., in charge of steam-turbine sales.

The Page Steel & Wire Co., 215 N. Michigan Ave., Chicago, Ill., announces the establishment of a welding service department; the appointment of J. J. Flaherty, with headquarters at Bridgeport, Conn., to direct sales of Armco high-carbon and low-carbon welding rod wire.

Wolff & Co., merchant engineers, Wrigley Building, Chicago, are now representing The Baker-Dunbar line of "Arrow" ash gates, cast-iron hoppers and sluiceways. This makes the fourth account for this sales agency which for some time had been representing the Andale Engineering Co., of Philadelphia; The Bartlett Hayward Co., of Baltimore, and the Cleveland Worm & Gear Co., of Cleveland.

The Pittsburgh Piping & Equipment Co., Pittsburgh, Pa., announces a merger with the American Foundry & Construction Co. The officials of the latter company will be connected with the new organization and the combined business will be operated by the Pittsburgh Piping & Equipment Co. A new plant is just being completed at 41st to 43rd Streets, Pittsburgh, which is expected to be in entire operation in a few months.

Coming Conventions

American Boiler Mfg. Association, H. N. Covell, 7 East 19th Ave., Brooklyn, N. Y. Meeting at Glen Spring Hotel, Watkins, N. Y., June 1-3.

American Electrochemical Society. Dr. Colin G. Fink, Columbia University, New York City. Convention at Niagara Falls, April 23-25.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Regional convention, at Swampscott, Mass., May 7-9. Annual convention at Saratoga Springs, June 22-26.

American Society of Mechanical Engineers—Calvin W. Rice, 29 West 39th St., New York City. Spring meeting at Milwaukee, Wis., May 18-21.

American Society of Refrigerating Engineers. William H. Ross, 35 Warren St., New York City. Convention at Milwaukee, May 18-21.

American Water Works Association. W. N. Niesley, 170 Broadway, New York City. Convention at Louisville, Apr. 27-May 3.

Electric Power Club. S. N. Clarkson, B. F. Keith Bldg., Cleveland, Ohio. Convention at Hot Springs, Va., May 26-29.

Exposition of Inventions—American Institute, E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Bldg., 29 West 39th St., New York City, April 27 to May 2.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

Mid-West Power Show at Milwaukee, Wis., May 18-21. Ralph H. Cahill, care of Mid-West Power Show, City Hall, Milwaukee, Wis.

National Association of Stationary Engineers. F. W. Raven, 417 South Dearborn St., Chicago, Ill. National convention and exhibition at St. Paul, Minn., Aug. 31-Sept. 4. Annual conventions and exhibitions of state associations are scheduled as follows: **Indiana State Association** at Purdue University, Lafayette, Ind., April 20-23. W. C. Knowles, Northern Indiana Gas & Electric Co., Lafayette, Ind. **Kansas Association** at Topeka, May 6-8. J. M. Van Sant 739 Horne St., Topeka. **Pennsylvania Association** at Pittsburgh, Pa., May 15-16. Frank J. McCarron, 3647 North 11th St., Philadelphia, Pa. **Wisconsin Association** at Milwaukee, May 18-22. F. W. Horn, 256 29th St., Milwaukee, Wis. **New Jersey Association** at Atlantic City, June 4-8. H. W. Vail, 1244 Park Ave., Plainfield, N. J. **New York Association** at McAlpin Hotel, New York City, June 11-13, W. T. Meinzer, 3rd St., near Warburton, Bayside, L. I. **Iowa State Association** at Ottumwa, June 16-18. F. L. Stocker, 127 S. Elm St., Ottumwa, Iowa. **New England States Association** at Worcester, Mass., July 10-12, formerly announced June 18-20. F. L. Tyler, 32 Briggs St., Taunton, Mass. **Ohio Association** at Middleton, Ohio, June 18-20. T. S. Garrett, 2622 East Second St., Dayton, Ohio. **Connecticut Association** at New Haven, June 25-27. George F. Klopfer, 30 East Pearl St., New Haven. **Michigan Association at Muskegon,** July 15-17. Charles Unterreiner, 5522 Underwood Ave., Detroit, Mich. **Minnesota Association** at St. Paul, Aug. 24-28. C. A. Nelson, 800 22nd Ave., Minneapolis, Minn.

National District Heating Association. D. L. Gaskell, Greenville, Ohio. Sixteenth annual convention at West Baden Springs Hotel, West Baden, Ind., May 19-22.

National Electric Light Association. M. H. Aylesworth, 29 West 39th St., New York City. Annual convention at San Francisco, June 15-20.

Society of Industrial Engineers. George C. Dent, 608 South Dearborn St., Chicago, National convention at Hotel Winton, Cleveland, Ohio, May 6-8.

Trade Catalogs

Electrodes, Welding—General Electric Co., Schenectady, N. Y. Booklet describing types A, B and C welding electrodes together with instructions covering the use of each.

Tanks—Conveyors Corp. of America, Chicago, Ill. "American Cast Iron Storage Tanks" is the title of a small booklet recently issued by the company to show the uses of this product.

Water Softeners — Paige & Jones Chemical Co., Inc., Hammond, Ind. Bulletin, "Zeolite Upward-Flow Water Softeners," describes this equipment with pictures and views of installations.

Evaporators—Wheeler Condenser & Engineering Co., Cateret, N. J. This catalog takes up the discussion of evaporators for distilled water for boiler feed, the fitting of evaporators into power-plant heat balance and the relation of the evaporators to other heat-balance equipment.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; *mine run* except Pittsburgh gas slack (*Coal Age*):

Bituminous, Net Tons	Market Quoting	April 6, 1925
Pool 1	New York	$2.50@$2.85
Smokeless	Boston	1.59
Clearfield	Boston	1.75@ 2.20
Somerset	Boston	1.90@ 2.35
Kanawha	Columbus	1.40@ 1.60
Hocking	Columbus	1.35@ 1.60
Pittsburgh	Pittsburgh	1.75@ 1.90
Pittsburgh gas slack	Pittsburgh	1.60@ 1.70
Franklin, Ill.	Chicago	2.25@ 2.50
Central, Ill.	Chicago	2.00@ 2.25
Ind. 4th Vein	Chicago	2.00@ 2.25
West Ky.	Louisville	1.25@ 1.50
S. E. Ky.	Louisville	1.25@ 1.50
Big Seam	Birmingham	1.50@ 2.00
Anthracite, Gross Tons		
Buckwheat No. 1.	New York	$2.00@$3.00
Buckwheat No. 1.	Philadelphia	2.00@ 2.50
Birdseye	New York	1.40@ 1.60

FUEL OIL

New York—Apr. 9, light oil, tank-car lots; 28@34 deg. Baumé, 6c. per gal.; 36@40 deg., 6¼c. per gal., f.o.b. Bayonne, N. J.

St. Louis—Mar. 31, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.90 per bbl.; 26@28 deg., $1.95 per bbl.; 28@30 deg., $2.00 per bbl.; 30@32 deg., $2.05 per bbl.; 32@36 deg., gas oil, 5c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Mar. 31, f.o.b. local refinery; 30@34 deg. fuel oil, 6¼c. per gal.; 36@40 deg., fuel oil, 6¾c. per gal.

Dallas—Apr. 4, f.o.b. local refinery, 26@30 deg., $1.80 per bbl.

Philadelphia—Apr. 3, 28@30 deg., $2.31@$2.373 per bbl.; 18@22 deg., $2.184@$2.247; 13@16 deg., $2.06@$2.123 per bbl.

Boston—Apr. 6, tank-car lots, f.o.b. heavy oil, 12@14 deg., Baumé, 4⅝c. per gal.; light oil, 28@32 deg. Baumé, 6c. per gal.

Cincinnati—Apr. 7, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5⅜c. per gal.; 26@30 deg., 6c. per gal.; 30@32 deg., 6¼c. per gal.

New Plant Construction

Ala., Tuscaloosa—City Council, plans improvements to waterworks system, including pumping station and main extensions. Estimated cost $175,000.

Ariz., Inspiration—Inspiration Construction Copper Co., is having plans prepared for a leaching plant, with conveying system, including trougher carriers, motors, drives, etc. Estimated cost $150,000. G. H. Booth, is engineer.

Calif., Garberville—J. E. Benbow, Eureka, plans irrigation of 102 acres, involving construction of dam, pumping plant, two 4 in. one 6 in. and one 8 in. centrifugal pumps, operated by 10 and 15 hp. electric motors.

Calif., Los Angeles — Hayward Hotel, Spring and 6th St., is having plans prepared for the construction of a 14 story, hotel on 6th St. Estimated cost $500,000. Parkinson & Parkinson, Title Insurance Bldg. are architects.

Calif., Los Angeles—Los Angeles Creamery Co., 1120 Towne Ave. has had plans prepared for the construction of a 4 story, cold storage plant. Gay Engineering Co., 2650 Santa Fe Ave., is engineer.

Calif., Quincy—R. B. Muir, 2765 Steiner St., San Francisco, representing owners, plans the construction of dam and power plant in Meadow Valley, near here. Equipment for power house includes double overhung, tangential impulse wheels, direct connected to electric generators.

Calif., San Francisco—St. Joseph's Hospital, Buena Vista and Park Aves. Plans the construction of a hospital. Estimated cost $500,000.

Fla., Miami—Palmer-Laramore Inc. plans the construction of a 16 story, hotel and office building, on Bay Shore Drive. Estimated cost $1,500,000.

Fla., West Palm Beach—W. J. Von Behrew, et. al. is having plans prepared for the construction of a 15 story hotel, on Poinsetta St. Estimated cost $700,000. W. M. King, is architect.

Fla., West Palm Beach — West Palm Beach Water Co. plans the construction of a 9,000,000 g.p.d. coagulating basin, steam turbine pumps 8,000,000 g.p.d., 200 hp. steam boiler, etc. Estimated cost $500,000.

Ga., Cedarstown — U. S. Finishing Co. plans the installation of a 500 hp. water tube boiler.

Ind., Gary — Little Bros. Packing Co., plans the installation of packing house equipment and freezing machinery, in plant at Racine, Wis.

Ill., Chicago—Board of Education, J. E. Byrnes, Bus. Mgr., 650 Clark St., will receive bids until April 21, for alterations, to boiler house, of McKinley High School, including 2 new boilers, vacuum pumps, etc., estimated cost $15,000; additions and alterations, heat regulators, ventilators, boiler house equipment, etc. for J. N. Thorp School, estimated cost $50,000; and alterations, including new boilers and equipment for boiler room, for Anderson School, estimated cost $15,000. J. C. Christensen, 650 South Clark St., is engineer.

Ill., Chicago—E. A. Borehert, c/o J. A. Nyden, 190 North State St., Archt. is having preliminary plans prepared for the construction of a 6 story hotel, on Hyde Park Blvd. Estimated cost $2,000,000.

Ill., Chicago — C. H. Bramwell, Hotel Drake, plans the construction of a 20 story hotel, on recently purchased site on Lake Shore Drive here. Estimated cost $1,500,000. Architect not selected.

Ill., Chicago—Shoreland Hotel Co., c/o Fridstein & Co., 111 West Washington St. Engr. and Archt. is having plans prepared for the construction of a 13 story, hotel at 5400 South Shore Drive. Estimated cost $8,000,000.

Ill., Evansville—L. Garries, 140 South Dearborn St., Chicago, is having plans prepared for the construction of a 7 story, hotel, on Sherman St., between Church and Bensen Sts., here. Estimated cost $2,000,000. S. N. Crowen, 10 South La Salle St., Chicago, is engineer.

La., Churchpoint — Mayor and Bd. of Aldermen, will receive bids until April 28, for construction of waterworks system, including, 50 hp. and 100 hp. crude oil engines, 500 gal. fire pump, motor driven; reservoir, etc. Swanson-McGraw, United Fruit Bldg., New Orleans, consulting engineers.

Mass., Lawrence—Dept. of Public Works, has engaged Morris Knowles, Inc., Engrs., 507 Westinghouse Bldg., Pittsburgh, Pa., to design and supervise construction of waterworks, improvements, consisting of filter plant, additional boiler and pumping equipment. Bids will soon be asked.

Mass., Shrewsbury — Commonwealth Ice Co., plans rebuilding of plant to replace fire loss. Estimated cost $50,000. Engineer not selected.

Mich., Detroit — C. H. Harrison 22,822 Woodward Ave., plans the construction of an 8 story, office building with steam heating system, on Woodward Ave. Architect's name withheld.

Mich., Detroit—Public Library Commission, Public Library, Woodward Ave., is having preliminary plans prepared for the construction of a heating plant to supply heat to library and Institute of Arts. on Farnsworth Ave. Estimated cost $200,000. Complete equipment will be required. J. S. Stringham, Clinton and Beaubien Sts., is city research engineer.

Minn., Bloomington (Minneapolis P. O.)— Minnesota Masonic Homes, Corp. c/o A. F. Pray, Chmn. Bldg. Comn., 300 Oneida Bldg., Minneapolis, awarded contract for the construction of a 100x100 ft. power house and laundry, to G. Schwartz & Co., Rochester. Estimated cost $75,000.

Minn., Minneapolis—City, F. S. Gram, Pur. Agt. is receiving bids for the refrigerating machinery, for new workhouse, to be built at Parkers Lake. N. W. Elsberg, is city engineer.

Minn., Waseca—Water & Light Board, H. E. Isker, mgr. will receive bids until May 5 for the construction of 770 ft. well, deep well pump, etc. Tolz, King, and Day, Builders Exchange, St. Paul, are engineers.

Miss., Aberdeen—City Water and Light Superintendent is authorized to expend $25,000 for purchase of deep well pump. W. P. Dabney, Columbian Tower Bldg., Memphis, Tenn. is engineer.

Mo., St. Louis—American Packing Co., 3845 Garfield Ave. will build an 80 x 115 ft. packing plant and cooler building, by day labor. Koerner Engineering Co., Syndicate Trust Bldg. is engineer.

Mo., Steele—City Clerk will receive bids until April 15 for two 125 g.p.m. motor driven centrifugal pumps, 75,000 gal. tank on tower, etc. Estimated cost $38,000. A. C. Moore, Joplin, is engineer.

N. J., Plainfield — Muhlenberg Hospital, H. H. Pond, Pres. Bd. Directors, plans the construction of a hospital addition. Estimated cost $500,000. Engineer not selected.

N. J., Trenton—F. W. Donnelly, City Hall, plans the construction of a 10 story hotel, at Broad and Hanover Sts. Estimated cost $500,000. Architect not selected.

N. Y., Brooklyn — Welsch Construction Co. c/o Shampan and Shampan, 188 Montague St., Archts., will build an apartment house, on Maple St., by day labor. Estimated cost $750,000.

N. Y., New York—Cedar Williams St. Corp. c/o Sloan and Robertson, 1 Pershing Sq., Archts., is having plans prepared for the construction of an 18 story, office building with steam heating system, at 40 Cedar St. Estimated cost $2,500,000.

N. Y., New York—J. Dorf, c/o G. & E. Blum, 505 Fifth Ave. archts., is having plans prepared for the construction of a 17 story loft building, including steam heating system at 49-57 West 37th St. Estimated cost $1,800,000.

N. Y., New York—15 East 69th St., is having plans prepared for the construction of a 15 story, hotel, with steam heating system, on Madison Ave., between 69th and 70th St. Estimated cost $1,000,000. G. F. Pelham, 200 West 72nd St., is engineer.

N. C., Asheville — La Fayette Development Co. plans the construction of a hotel "Chateau La Fayette" on Stradley Mountain, here. Estimated cost $1,000,000. Wiggins Hotel Co. is lessee.

N. C., Hamlet—City, plans additions to waterworks system, including coagulating basin, filters, and alterations in pumps and motors. Estimated cost $60,000.

N. C., High Point—J. W. Hendrick, Mayor, and City Council, will receive bids until April 28th, for furnishing 4 motor driven and 2 gasoline engine driven centrifugal pumping units, with starters and appurtenant equipment. Also for construction of addition to River and City pumping stations and filter plant, etc. W. C. Olsen, Raleigh is consulting engineer.

N. D., Grand Forks—University of North Dakota, T. F. Kane, Pres., plans to purchase equipment for power plant, at State University, State legislature has authorized $24,650.

O., Canton—Thomas & Maxwell, 12th St., N. E., plan the construction of a 2 story addition to ice manufacturing plant at 12th and Cherry St. N. E. Estimated cost $40,000.

O., Cincinnati—C. P. Taft, 316 Pike St., awarded contract for the construction of a 12 story apartment on Fourth St. to Ohio Building and Construction Co., Burnet Ave. $2,000,000.

O., Cleveland—Ajax Manufacturing Co., 3830 Lakeside Ave. is in the market for 10 motors, up to 50 hp., a.c. and d.c. for new plant.

Okla., Elk City—City, L. A. Ross, Clk. plans additions to waterworks system, including 12 new wells, pumps, pumphouses, motors, etc. Estimated cost $139,000. Benham Engineering Co., Gumbel Bldg., Kansas City, Mo., is engineer.

Okla., Oklahoma—G. L. Miller Co., Hurt Bldg., Atlanta, Ga., has had plans prepared for the construction of an 8 story hotel including steam heating system, at 15th St. and Robinson Ave., here. Estimated cost $1,250,000. Hawk & Parr, Cotton Exchange, are architects.

Pa., Philadelphia — J. C. Kohn, Mom's Bldg., awarded contract for the construction of a 16 story, office building to Wark Co., 1600 Walnut St. Estimated cost $1,500,000.

Pa., Philadelphia—McCallum Apartment Corporation, c/o J. Bernhood, 13th St. and Walnut Pl. awarded contract for the construction of a 9 story, apartment house at McCallum and Hortner Sts. to Wark Co., 1600 Walnut Pl. Estimated cost $1,200,000.

Pa., Philadelphia—B. Shulman, 1722 Arch St., Archt., is preparing preliminary plans for the construction of an 8 story hotel. Owner's name withheld.

Tex., Cuero—City Commission plans an election to vote $150,000 bonds for construction of electric light and power plant. Engineer not selected.

Tex., Denton—W. McKennie, Sr., Gainsville, and W. McKennie, Jr., Dallas, plan the construction of an ice plant at East Mulbery and Bois d'Arc St., here. Estimated cost $50,000. R. H. Roark, 1007 North 22nd St., Waco, is engineer.

Tex., El Paso—C. De Groff, c/o Hotel Orndoroff, 300 Nesa Ave., plans the construction of a 11 story, hotel, with ventilating, heating system, and 4 electric elevators, at Mills and Mesa St. Estimated cost $1,000,000. Trost & Trost, Two Republics Bldg., are engineers and architects.

Tex., Fredericksburg—City plans an election to vote $120,000 bonds for waterworks system, including pumping equipment, etc. Terrell Bartlett Engineers, 612 Calasieu Bldg., San Antonio, are engineers.

Tex., Wichita Falls—D. L. Cross, Linz Bldg., and W. P. Lincoln, 5400 Gaston Ave., Dallas, plan the construction of an ice plant, here. Estimated cost $50,000. Architect not selected.

Ont., Campbellford — Water and Light Commission, S. J. Abernethy, Chr., plans the installation of a gasoline driven, 1,000 g.p.m., 3 stage, centrifugal fire pump. Estimated cost $8,000.

Ont., Humberstone—Town Council, J. J. Wychmann, Clk., plans the construction of a waterworks system, including valves, electric centrifugal pumps, pumphouse, reservoir, etc. Estimated cost $30,000. Engineer not selected.

Ont., Kenora—Backus Brooks Co., will build a hydro-electric power plant 18,000 hp. and dam, including turbines, generators, etc. Estimated cost $3,000,000. J. T. McLennan, is engineer. Work to be done by owners.

Que., Sherbrooke—Hospital St. Vincent de Paul, awarded contract for the construction of a 4 story hospital to G. A. Dion, $410,000. J. W. Gregorre is architect.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

With the exception of continued firmness in steel rivets, prices of most power-plant and electrical supplies are lower than at this time last month. Declines were noted in linseed oil, red and white lead, babbitt and other non-ferrous metal products, boiler tubes, armored cable, conduit, elbows, couplings and rubber-covered copper wire.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, single jacket		56c. per ft.
Common, 2½-in., cotton-rubber lined	80c. per ft. list less	45%

Air—Best grade

¼-in., per ft.	3-ply	$0.33	4 ply	$0.40

Steam—Discounts from List

First grade 40%	Second grade	40-5%	Third grade	40-10%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50-5%	Second grade	50-10-5%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40-2½%
Heavy	30-5%

RAWHIDE LACING { For cut, best grade, 45-5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45-5%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ⅛ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ¼- and 1-lb. balls	50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	15@22	19.00	.14@.16
Colored	10.00@15.50	18.00	.09½@.12½

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	11.00	11.00
New York	9.25@9.75	...
Cleveland	$36.00 per M.	$50.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.09	$1.24	$1.25

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	15.75	15.00	17.25	16.50
White	15.75	15.00	15.75	15.00

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Rivets, ⅞x1-in. and longer, 19c. per lb., less 50% at New York warehouses. Same discount for tinned. EXTRA per 100 lb. for 1½ to 2-in. long, all diameters, 25c.; ⅝-in. dia., 35c.; ½-in., dia., 75c.; 1-in. long and shorter, 75c.; longer than 5-in., 50c.; less than 200 lb., 50c.; countersunk heads, 45c.

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.:

New York	$4.50	Chicago	$3.50	Pittsburgh	$2.50@2.60
Boiler rivets, same sizes:						
New York	$4.60	Chicago	$3.70	Pittsburgh	$2.85@2.90

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$47@52
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@27
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	26@31
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@45
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana	per M	33@40
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	40@43
Chrome ore crude, 40@50%	net ton	18.00@19.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	63.00	50.00
(35% tin)	28.00	20.50	28.00

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.15	$4.00	$3.80
Flats, squares and hexagons, per 100 lb. base	4.65	4.50	4.30

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17 07
1¼	.....	.....	19 20
1½	.....	$38 00	17 92
1¾	.....	28 50	20 48
2	$17.33	25 00	20 24
2¼	19 84	28 25	23 00
2½	21 60	34 00	26 03
3	25.50	42 50	27 04
3¼	.....	49 50	30 67
3½	31.50	52 75	33.33
4	38.03	67.00	40.11

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.
These prices are net per 100 ft. based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.
In addition to the above, standard cutting charges are as follows:
2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3¼ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft
No. 14 solid	$37.50 (net)	$ 52.00 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

		Lead Covered
Less than coil lots	50%	25%
Coils to 1,000 ft.	55%	30%
1,000 to 5,000 ft.	60%	35%
5,000 ft. and over	60–5%	40%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
¼	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
⅜	72.07	78.63	10.21	11.63	6.46	7.03
½	103.31	113.00	15.10	17.21	8.39	9.13
¾	139.77	152.88	20.51	23.07	11.78	12.75
1	167.12	182.79	27.34	30.76	14.56	15.75
1¼	224.85	245.94	50.13	56.40	19.41	21.01
1½	355.50	388.85	82.03	92.28	27.73	30.01
2	464.88	508.50	218.74	246.10	41.59	45.01
2½	585.30	637.74	483.04	543.46	55.46	60.02
3	714 17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$23.00
No. 16 cotton reinforced heavy	26.50
No. 18 cotton reinforced light	18.25
No. 16 cotton reinforced light	23.00
No. 18 cotton Canvasite cord	17.50
No. 16 cotton Canvasite cord	20.50

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30 amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60 amp.	100	30	35-amp. to 60-amp.	100	.60
61-amp to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp to 600-amp.	0	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500)	$2.85
0–30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	45	.55	60
25	.27	.32	120	100	.50	.55	24
40	.27	.32	120	150	.65	.70	24
50	.27	.32	120	200	.80	.85	24
60	.32	.37	120	300	1.25	1.35	24
				500	2.00	2.15	12
				750	3.50	3.70	8
				1,000	3.75	3.95	8

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.08½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6.85	$9.01	$10.75	$17.25
12	8.96	11.60	13.40	22.25
10	12.14	18.42	17.20	29.60
8	17.50	20.98	22.60	41.58
6	.....	.....	32.45	.....
4	.....	.....	45.80	.....
2	.....	.....	68.00	.....
1	.....	.....	86.95	.....
0	.....	.....	112.60	.....
00	.....	.....	133.00	.....
000	.....	.....	159.00	.....
0000	.....	.....	189.00	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	⅜ In Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 33c. lb., 100 lb. lots	31c lb.
Rubber tape, ¾ in., less 100 lb. 33c. lb., 100 lb. lots	31c lb.
Wire solder, less 100 lb. 27c. lb., 100 lb lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%